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Spectrophotometry of Clarified Cell Suspensions

R. Barer

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MANY living cells contain pigments that may have important or even essential physiological functions; in other cases pigments accumulate as a result of pathological conditions. The investigation of the absorption spectra of these pigments is a valuable aid to their identification. Most of our knowledge of such substances is based on work carried out with extracellular solutions, the preparation of which necessitates the death and disruption of the cell. It is often very desirable to study these pigments *in situ* within the intact living cell, for only in this way can their true physiological functions be established.

There are many other important reasons for investigating such spectra *in vivo*. It is by no means always certain that pigments exist in the same condition within the living cell as they do in extracts. There is good evidence, for example, that many of the chlorophyll-type pigments normally exist in the form of complexes with cellular proteins, and that their absorption spectra are considerably modified as a result (*1*). This would explain the fact that, although different species of red-purple bacteria exhibit important differences in absorption spectra in suspension or in colloidal extracts, the pigments obtained from all species by extraction with organic solvents give identical spectra.

Another well-known example of the effect of combination with proteins is the change in absorption spectrum of heme groups in substances such as hemoglobin, catalase, and the cytochrome pigments. Quite apart from the question of combination with other substances, an intracellular pigment might be present in the colloidal state, in simple aqueous solution, dissolved in lipids, or adsorbed and possibly oriented at interfaces. Its absorption spectrum in these conditions might be very different from that in simple solution. Moreover, the absorption spectra of many substances are influenced by the nature of the solvent and particularly by the *p*H, which may not be the same *in vivo* as in the extract.

As a rule the concentration of intracellular pigments is too low to allow them to be investigated in single cells, although some exceptions may be found in the case of hemoglobin and chlorophyll, the intracellular spectra of which have been determined by microspectrographic methods (*2*). In general, however, it is necessary to use cell suspensions to obtain a sufficient concentration of pigment. Such suspensions are almost invariably cloudy, or even quite opaque, because of light scattering. It is extremely difficult to obtain satisfactory spectra under these conditions. The absorption bands become diffuse, and fine details are lost. The apparent absorption remains high even in regions of the spectrum in which there is no true absorption by pigment, so that the ratio of peak to trough is reduced.

Various methods for correcting the effect of scattering have been suggested, but none are very satisfactory. A more promising approach might be to eliminate scattering as far as possible rather than to correct for it. The fundamental cause of scattering in cellular suspensions is the presence of refractive index gradients between the cell surface and the mounting medium and between intracellular structures and the cytoplasm. Following the development of a method of immersion refractometry applicable to living cells (*3*), an attempt was made to reduce light scattering in suspensions by immersing the cells in a medium having as nearly as possible the same refractive index as that of the cells.

The first step is the determination of the refractive index of the peripheral region of the cell that is in contact with the medium. The basic principle is to examine cells by phase-contrast or interference microscopy when they are immersed in protein solutions of different concentrations. The protein that has been generally used for this work is Armour's Bovine Plasma Albumin, fraction V. As the refractive index of the medium is raised, the contrast of the cells becomes progressively lower until at the match point the cytoplasm is frequently invisible. At still higher concentrations the contrast becomes reversed so that if, for example, a positive phase-contrast objective which normally gives dark contrast is used, the cytoplasm will appear bright. Because of biological variation it is rarely possible to match simultaneously all the cells of a suspension accurately, but as a rule the range of refractive indices is not great, and it is easy to determine a mean protein concentration at which the majority of the cells are matched.

After this preliminary determination a suspension of cells can be made up by adding a suitable quantity of packed cells to a protein solution of the correct concentration. The results of this procedure are usually quite dramatic, and a suspension of pigmented cells that appears quite opaque in its normal medium may become almost completely transparent.

A typical example is shown in Fig. 1, which is a photograph of two suspensions of a pigmented bacterium contained in identical spectrophotometer cuvettes. The suspension on the right is made up in or-

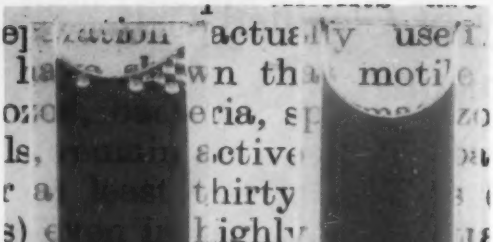

Fig. 1. Two suspensions of *Rhodopseudomonas spheroides* containing the same number of cells per unit volume. The suspension on the right is made up in aqueous culture medium, that on the left in a protein solution having the same refractive index as most of the cells.

dinary culture medium and is so opaque that no printing can be seen through it. The suspension on the left contains approximately the same concentration of cells, but these are suspended in a 30-percent protein solution. Although the suspension is deeply pigmented, it is nevertheless reasonably transparent, and the printing can be read through it. The degree of improvement that can be obtained by such methods depends on the type of cells and on their concentration. The best results are obtained with relatively homogeneous, highly pigmented cells, such as mammalian red blood corpuscles and many pigmented bacteria.

If the cells are very inhomogeneous, however, and contain numerous granular structures differing greatly in refractive index from that of the cytoplasm, there will be some residual scattering. As a rule scattering from this cause does not appear to be very important, except when the granules are large and dense. For example, many green algae have given excellent results, but in the case of some Euglenidae that have large dense chloroplasts the degree of clarification has been less good.

In general, however, the main site of scattering seems to be at the cell surface, probably because the sharpest gradient of refractive index occurs there. The concentration of cells also affects the degree of clarification that can be achieved because the number of cells whose refractive indices are not exactly matched by that of the medium will increase with concentration. If the pigment to be investigated is present in a sufficient amount to give a high optical density with comparatively few cells, very good results can be obtained. If, on the other hand, very dense suspensions are required, as is usually the case, for example, for work on the cytochromes, less clarification occurs.

The clarified suspension can be handled in the same way as an ordinary solution, and its absorption spectrum can be measured in an ordinary spectrophotometer. For the present work (*4*) a Hilger Uvispek instrument has been used. The slit widths used have corresponded to a spectral resolving power of 5 A, and measurements have usually been made at intervals of 5 mμ or less.

The Bovine Plasma Albumin solution is faintly yellow in color and shows a very weak absorption band at 405 mμ in the oxidized state and at 425 mμ in the reduced state. The absorption in this region is rarely strong enough to cause trouble, and in any case spectra are measured relative to a blank containing the same concentration of protein. The protein also exhibits a much stronger absorption band at 278 mμ, and the presence of this makes it impossible to measure spectra at wavelengths below about 310 mμ.

A few typical results are shown here, but a more detailed account is in preparation.

Red cells (*5*). Mammalian erythrocytes are excellent for demonstrating the principles of the method. A suspension of red cells in a suitable protein solution (about 35 percent w/v) is actually less cloudy than a lysed suspension containing the same amount of hemoglobin. The latter contains ghosts that still scatter light slightly, whereas the clarified suspension is free from this effect. The investigation of the hemoglobin spectrum in intact suspensions is of particular interest, because it is well known that the existence of the intense Soret band at 414.5 mμ (for oxyhemoglobin) is very difficult to demonstrate in cloudy suspensions. It has even been suggested that hemoglobin exists in a different state in the intact cell from that in solution (*6*). Keilin and Hartree (*7*), however, considered that the apparent absence of the Soret band was an optical effect, and Rubinstein and Ravikovich (*8*) suggested that forward scattering of light was responsible. Certainly the Soret band can be demonstrated in single intact red cells by microspectroscopy (*2*), and its disappearance from the spectrum of cloudy suspensions shows how misleading results obtained with the latter may be.

A typical absorption spectrum of a clarified suspension of human red cells is shown in Fig. 2. This shows

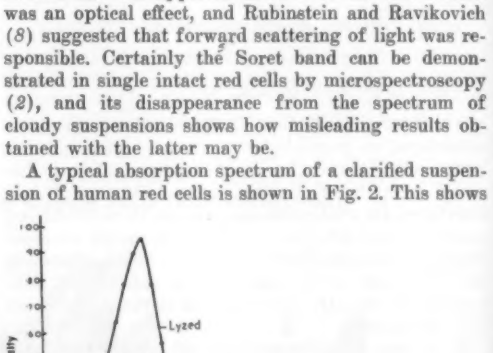

Fig. 2. Spectra from a clarified suspension of intact human red cells and from the same suspension after lysis.

the presence of a strong Soret band as well as the two weaker visible bands, all at the normal position for oxyhemoglobin. Similar curves showing characteristic shifts in the bands can be obtained with cells exposed to carbon monoxide. At first sight such curves appeared highly satisfactory, and it seemed as if almost all trace of scattering had been eliminated. However, a simple experiment showed that this was not the case. A trace of saponin was added to both the suspension and the blank, and the spectrum was redetermined. No change was observed except in the region of the Soret band, at which the optical density was doubled.

This effect has been investigated in some detail and the most likely explanation seems to be that it is caused by anomalous dispersion at a strong absorption band. Thus the refractive indices of the cells are matched by the protein at wavelengths above and below the Soret band, but in the immediate region of the latter sharp changes in refractive index occur in the hemoglobin, so that the cells are no longer matched in index by the protein. Thus, although considerable reduction of forward scattering has resulted, scattering is still not completely eliminated in the Soret band region. By using much more concentrated suspensions, it has been possible to demonstrate very slight anomalous dispersion effects in the weaker visible bands. The possible existence of such effects may make it difficult to apply this technique quantitatively, but it should be remembered that anomalous dispersion is likely to occur to any important extent only in the region of extremely intense absorption bands.

Algae. Spectra have been obtained from several different varieties of algae. Figure 3 illustrates a typical result obtained with *Chlorella variegata.* Cultures of this alga contain colonies varying from yellow through yellow-green to deep green, and the spectral changes during the development of the green pigment have been followed. The general features of this spectrum are similar to those described by Emerson and Lewis (*9*), but the bands are sharper and additional details can be made out. The position of the two main chlorophyll peaks is slightly variable. Rabinowitch (*1*, p. 700) comments that previous workers have given positions for the red peak varying from 668 to 680 mμ. I have not found variations as great as this, the usual range being between 675 and 680 mμ. Slight differences are found in other green algae, such as *Scenedesmus obliquus,* in which the peak occurs at 675 mμ and *Closterium,* in which it is situated at 677.5 mμ. Minor variations also occur in the position of the violet peak, which usually lies between 435 and 440 mμ. *Closterium* gives a sharp peak at 436 mμ (Fig. 4).

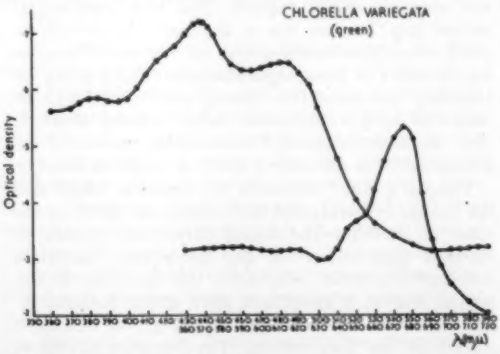

Fig. 3. Spectrum of a clarified suspension of a deep-green specimen of *Chlorella variegata.*

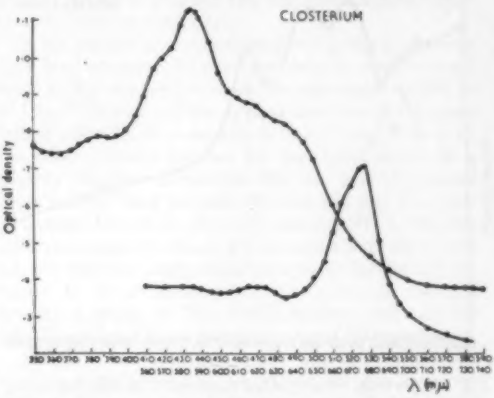

Fig. 4. Spectrum of a clarified suspension of *Closterium.* The bands caused by chlorophyll B are absent.

In all green algae so far investigated there is a distinct band at about 385 mμ. This does not appear to have been observed previously, probably because scattering in unclarified suspensions becomes very serious at short wavelengths and no observations appear to have been made below 400 mμ. This band probably corresponds to the chlorophyll-A band at about 380 mμ in organic solvents. Another band not shown on the diagrams has also been found at about 340 mμ; this probably corresponds to the 330-mμ band of chlorophyll A *in vitro.* The spectrum of *Closterium* shows certain interesting features. The hump at about 640 to 650 mμ that is characteristic of the *Chlorella* spectrum is absent, and the broad band at about 480 mμ is relatively weak compared with that of *Chlorella* and *Scenedesmus.* The former band can be ascribed to chlorophyll B, which is absent in *Closterium.* The latter band is generally said to be caused by carotenoids, but it is possible that the absorption in this region may be partly the result of another chlorophyll-B band that is masked by carotenoid bands. Observations on different spectra of *Chlorella variegata* lend some support to this view, although definite proof is lacking. There is another weak band at 620 mμ; this is particularly marked in *Closterium* because of the absence of chlorophyll B, but it can still be made out in *Chlorella.* This band, too, does not appear to have been observed previously; it probably corresponds to the 612-mμ chlorophyll-A band *in vitro.*

In all green algae so far examined the optical den-

sity remains surprisingly high throughout the green region. This has been commented on by Rabinowitch (*1*, p. 716) in the case of leaf spectra. It seems unlikely that this high optical density can be accounted for by scattering losses alone, for the refractive index match is usually made with green light, and one would expect minimum scattering in this region. It may be that other substances, such as pheophytins, are absorbing light of these wavelengths.

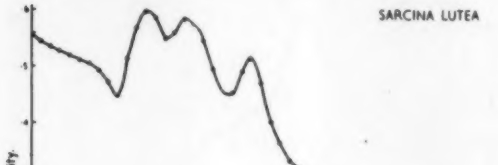

Fig. 5. Spectrum of a clarified suspension of *Sarcina lutea* showing well-marked carotenoid bands.

Pigmented bacteria. A large number of bacteria have been investigated by this technique. In many cases the pigmentation is caused by carotenoids. Figure 5 shows the spectrum of a clarified suspension of *Sarcina lutea*, which exhibits three typical carotenoid bands with maxima at 420, 440 to 445, and 475 mμ. Work on the extracted carotenoids (sarcinene, sarcinoxanthin) has been summarized by Goodwin (*10*) who gives the positions of the maxima as 415, 440, and 469 mμ in light petroleum, and 423, 451, and 480 mμ in chloroform. The *in vivo* spectrum thus appears to be intermediate between the spectra in these two solvents. Since the absorption bands of many carotenoids often show pronounced shifts in the colloidal state, these results suggest that sarcinene is present in the living cell in noncolloidal form, possibly dissolved in lipids.

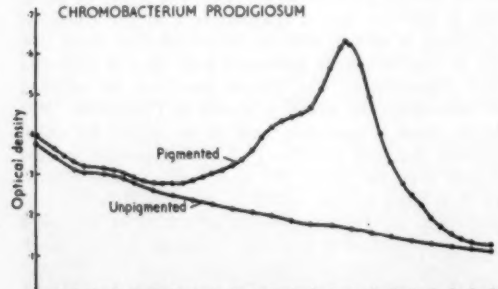

Fig. 6. Spectrum of clarified suspension of *Chromobacterium prodigiosum*. The spectrum of an unpigmented variety is shown for comparison. Note the presence of a weak band at 420 mμ in each case.

An example of a noncarotenoid pigment is shown in Fig. 6, which is the spectrum of *Chromobacterium prodigiosum* (*Serratia marcescens*). The spectral properties of prodigiosin, a tripyrrylmethene pigment, have been investigated by Hubbard and Rimington (*11*) *in vitro*. The pigment is insoluble in water, and in acidic organic solvents it shows a peak at 540 mμ and a shoulder at 510 mμ. The substance behaves as an indicator, and its spectrum changes considerably in alkaline solution.

The *in vivo* spectrum is interesting in that it appears to be virtually identical with the published spectrum obtained in acid ethanol or chloroform. This may throw some light on the state of the pigment in the living cell. In the first place, it would appear that the intracellular *p*H is on the acid side of neutral. Second, in view of the fact that the *in vivo* spectrum is so similar to the solvent spectrum, it seems unlikely that the pigment is conjugated with protein. Finally, the fact that the extracted pigment is insoluble in water suggests that it may be dissolved in cell lipids *in vivo*. One slight difference was observed between the spectrum of the suspension and that of the extract. The former shows evidence of a weak band at about 420 mμ which is not present *in vitro*. Fortunately, it was possible to obtain an unpigmented variety of the same bacterium, and its spectrum is also shown on Fig. 6. The slight hump at 420 mμ is still present, but the other bands have disappeared. This additional band is thus not related to prodigiosin but may, perhaps, be caused by carotenoids or the Soret band of a cytochrome pigment.

Photosynthetic bacteria: Red-purple bacteria. Although the absorption bands in the near infrared region of the spectrum were examined by Wassink *et al.* (*12*) in the case of a number of red-purple bacteria, little reliable information is available concerning the *in vivo* spectra of these organisms in the violet and near ultraviolet regions. This is a particularly serious gap, because one of the main bacteriochlorophyll absorption bands occurs at 375 mμ. The carotenoid bands in these organisms also exhibit many interesting variations. It is clearly unsatisfactory to attempt to assign absorption bands without studying their positions in spectra from a wide variety of organisms over as complete a spectral range as possible.

Figures 7 and 8 illustrate the dramatic effect that the change in carotenoid metabolism can have on the color of bacteria. The dotted curves are spectra of clarified suspensions of the red-purple bacterium *Rhodopseudomonas spheroides*. One day, for no apparent reason, a subculture grew green bacteria instead of red. The spectrum of the green variety is shown in the full curves. The bacteriochlorophyll bands that occur at 375, 585, 795, and 845 mμ are very similar in form and intensity. The carotenoid bands,

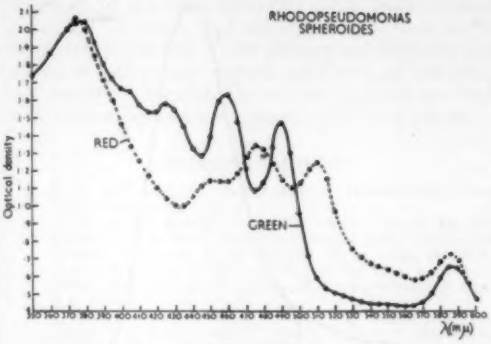

Fig. 7. Spectrum of clarified suspensions of red and green varieties of *Rhodopseudomonas spheroides*. The difference in color is due to the presence of a different carotenoid.

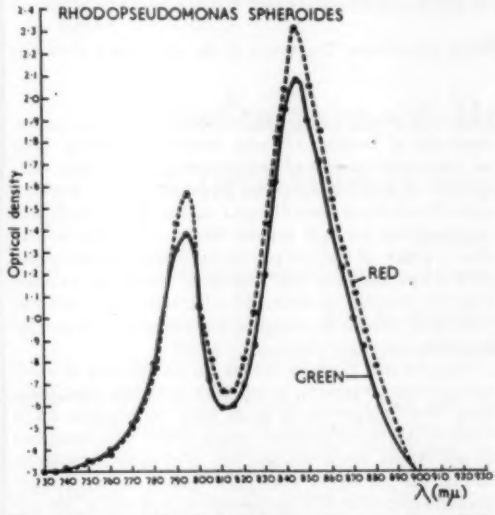

Fig. 8. Same as Fig. 7, but showing the very close similarity of the spectra in the infrared region.

on the other hand, are quite different, and the fact that the new maxima between 400 and 520 mμ correspond roughly with the minima in the spectrum of the red variety shows that the change is due not to the presence of an additional carotenoid but to one or more completely new carotenoids. The reason for the color change is simply that, in the green variety, there is no absorption band between 510 and 570 mμ, whereas in the red variety there is a strong band at 510 mμ with a residual absorption that remains high throughout the green and yellow regions. This, combined with the fact that the maximum sensitivity of the human eye lies in the green region, is responsible for the very obvious color change. The examination of several different strains of red-purple bacteria makes it reasonably certain that there is no sharp band that can be assigned to bacteriochlorophyll at about 420 mμ, as has been claimed (*13*).

The general pattern of the *in vivo* absorption spectrum of red-purple bacteria appears to be as follows. There are four bands that can be assigned to bacteriochlorophyll. Two of these, at 375 mμ and at 585 mμ, are rather constant in position, particularly the former. Occasional slight variations have been observed in the 585-mμ band. Two other bands are found in the near infrared region; these show rather more variation in position and very considerable variations in relative intensity.

In the strains so far examined two general patterns have been observed. In one type there is a fairly weak band at 800 mμ, with a much stronger band at 870 to 875 mμ. The ratio of the optical densities at the maxima of these bands is usually between 2 and 5 to 1. In the other common pattern the first band occurs at a slightly shorter wavelength, 795 mμ, and the second more intense band between 845 and 855 mμ. The ratio of optical densities is generally about 1.5 to 1. The two most prominent bands at 375 mμ and about 850 or 870 mμ are approximately equal in optical density. In addition to these bacteriochlorophyll bands, there is usually a group of four bands between 400 and 560 mμ. These are almost certainly caused by carotenoids.

It would be unwise to make dogmatic statements until a very large number of strains has been examined, but at present there appears to be some indication that the infrared pattern with bands at 800 and 870 mμ is associated with the presence of a carotenoid band at about 550 mμ. No sign of such a band has been found in strains giving the other type of infrared pattern, and indeed no carotenoid bands at wavelengths longer than 520 mμ have been found in such strains.

It seems to be generally agreed that all red-purple bacteria yield the same bacteriochlorophyll pigment on extraction with organic solvents, and it has been suggested that the differences in infrared spectra *in vivo* are the result of the conjugation of the same pigment with different proteins in the living cell (*12*). It may very well be that a certain type of metabolism associated with the production of a certain type of protein is also associated with the production or presence of a specific carotenoid. This is a possibility that requires further investigation.

Green bacteria. The investigation of these organisms is of some interest, because they form a poorly defined group that has been little studied in the past. Metzner (*14*) considered that they contained a pigment that was different from both ordinary plant chlorophyll and the bacteriochlorophyll of red-purple bacteria. He called this pigment bacterioviridin. Since, however, he was unable to carry out a proper spectrophotometric investigation in the violet region, his conclusions cannot be accepted with confidence.

A number of species of *Chlorobium* have been examined and have given particularly well-clarified suspensions. Figure 9 shows a spectrum of a typical deep-green variety. This shows two main absorption bands

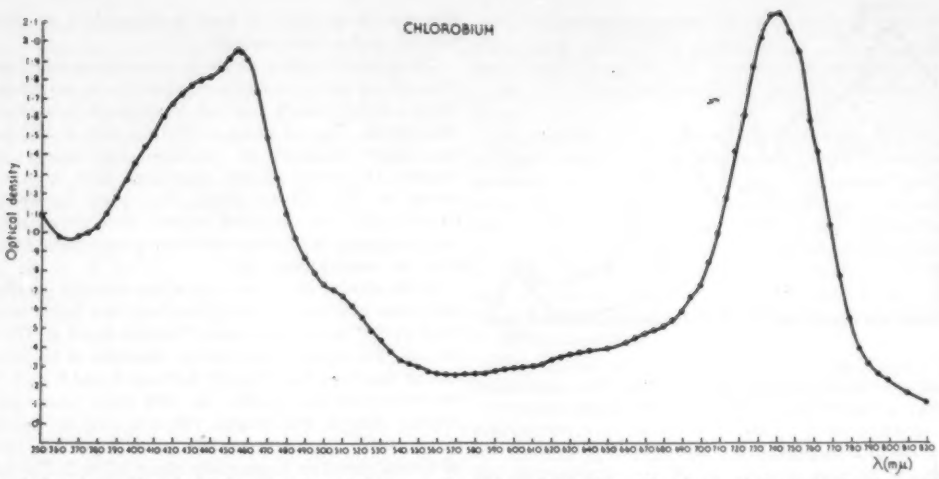

Fig. 9. Spectrum of a clarified suspension of the green bacterium *Chlorobium*. The shape of the violet band should be compared with those in Figs. 3 and 4.

at 455 and 745 mμ. There are a number of minor bands or shoulders, notably at about 430 and 510 mμ. The most striking feature of this spectrum is the remarkable superficial similarity of the broad violet band to the violet bands in green algae such as *Chlorella* and *Closterium*. Except for the fact that the maximum absorption in algae occurs at about 435 mμ and that in *Chlorobium* at about 455 mμ, the corresponding parts of the band are almost superimposable. The strong red band is also generally similar to that of *Closterium*, even though it occurs at a longer wavelength.

At first sight, therefore, one might be tempted to assume that the *Chlorobium* spectrum was simply caused by chlorophyll A conjugated with some specific protein that produced the rather marked wavelength shift. However, further experiments on purified extracts carried out with V. S. Butt showed that the extracted pigment, although possessing spectral properties very similar to those of chlorophyll A, did show certain important differences, particularly in its behavior during chromatography. Work on the further purification and identification of this pigment is in progress.

Recently it has been claimed that green bacteria contain a pigment identical with the bacteriochlorophyll of red-purple bacteria, and that bacterioviridin is an artifact or decomposition product (*15*). It is a little difficult to understand this claim, for it conflicts with the evidence of all previous workers on the subject (*16*). Seybold and Hirsch give *in vivo* spectra of green and red-purple bacteria in nonclarified suspensions. On examining these, it is seen that the spectrum given for "Purpurspirillen" (presumably *Rhodospirillum rubrum* or a related species) contains a very strong absorption band at about 750 mμ. This is a very remarkable finding, since such a band has never been observed, either by myself, or in the extensive investigations of Dutch (*12*) and American workers (*17*) on numerous species of red-purple bacteria. One cannot, of course, dismiss the possibility that Seybold and Hirsch have found a new strain with a different pigment, but perhaps a more likely suggestion is that their culture of red-purple bacteria was contaminated with green bacteria and that their spectrum exhibits features common to both. At all events, the spectrum they show cannot be accepted as typical of red-purple bacteria.

Seybold and Hirsch's curves for the spectra of various pigment extracts in organic solvents also illustrate how dangerous it is to base conclusions on a study of a limited spectral range. Their measurements do not extend below 400 mμ, yet, as already mentioned, one of the strongest absorption bands of red-purple bacteria occurs at 375 mμ *in vivo* and at about 360 mμ *in vitro*. In the green bacteria, on the other hand, the main violet band occurs at 455 mμ *in vivo* and 434 mμ *in vitro*. No bands are found at 360 to 380 mμ. The general shape of the bands and the distribution of minor bands is also entirely different.

The question whether green bacteria contain carotenoids has also been debated in the past. Van Niel and Muller (*18*) were unable to find any carotenoids in these organisms, but recently Butt and I have been able to separate a carotenoid, tentatively identified as gamma carotene, from some of the yellow-green varieties. The latter also appear to show interesting deviations in the *in vivo* spectrum. The main red band is shifted slightly to 750 mμ, and its optical density is much less than that of the violet band. A fairly weak but very distinct band appears at about 672 mμ. If the cultures are left for a few days in the spectrophotometer cuvette, the band at 750 mμ becomes weaker, whereas that at 672 mμ becomes stronger and

sharper. At the same time, the violet band changes somewhat in shape, and maximum absorption shifts from 450 to 423 mμ. These changes are probably the result of unfavorable growth conditions or autolysis. An attempt to separate the various pigments involved and to investigate their nature is now in progress.

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Production of Radioactive Organic Compounds with Recoil Tritons

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THE methods that have been widely used for the introduction of radioactivity into molecules are chemical synthesis, biosynthesis, and isotopic exchange. Even when these methods are feasible, they are often costly and time-consuming, and the need has been felt for a more direct technique. Exploitation of the momentum properties of nuclei formed in nuclear events offers the possibility of such a technique through incorporation of radioactive recoil atoms into previously inactive molecules. In this paper (*1*) a method is proposed that appears to be generally useful for the direct labeling of organic compounds by means of recoil tritons.

When a nuclear transformation occurs the emission of a particle or γ-ray usually gives the resulting species a recoil momentum that is very large in chemical terms. Such recoil or "hot" atoms, often having an energy of many thousands of electron volts, usually break the bonds attaching them to the parent molecules and in a condensed medium travel for at least several atom diameters before being reduced to thermal energy. During this journey they have sufficient energy to break bonds and they may then combine chemically with one of the fragments produced (*2–4*). If the hot atom is radioactive, a tagged molecule will then have been formed. In general it is likely that the new molecule will be a degradation product of the parent species.

The recoil behavior of radioactive halogen atoms following neutron capture in organic solutions has been extensively investigated (*2, 4*). Depending on the nature of the parent compound, a large number of radioactive species may be formed, most of which can be considered degradation products of the original molecule. A number of experimenters have shown that the $N^{14}(n,p)C^{14}$ reaction carried out in nitrogen containing organic compounds (*5, 6*) results in the production of many C^{14}-labeled organic compounds, although only a small fraction of the activity is to be found in the original compound irradiated. For instance Wolf and Anderson (*6*) made a careful investigation of the acridine case and found that only about 3 percent of the C^{14} formed was retained in the parent compound.

Schrodt and Libby have recently produced radioactive aliphatic hydrocarbons by dissolving nitrogen compounds in them and irradiating the solution in the pile (*7*). Using normal pentane, 25 percent of the

total C^{14} produced was found to be in the form of labeled *n*-pentane. This method thus seems to be of considerable promise for the production of tagged compounds in those cases where a homogeneous nitrogen-containing system can be prepared. The technique appears, however, to be considerably less efficient for cyclic compounds.

Tritium and C^{14} are the only radioactive isotopes that are generally useful for tagging organic compounds. The use of tritons rather than C^{14} recoils may be expected to have several important points in its favor. The number of recoil atoms that can be introduced into an organic compound is usually limited by the amount of radiation the system can withstand before being destroyed. Thus the 12.5-yr half-life of tritium is distinctly more convenient than the 5600-yr half-life of C^{14}, since for a given number of radioactive atoms the specific activity of a labeled compound will be 450 times higher for tritium than it will be for C^{14}. Moreover, recoil tritons need break only a single bond and displace a single proton to be incorporated in the compound to be labeled; in the analogous case of C^{14}, several bonds must be broken, and in most cases the carbon skeleton of the compound must be disrupted to admit the tracer atoms. It therefore seems reasonable—especially for complex compounds—that the introduction of recoil tritium is less likely to result in degradation of the parent compound.

Studies of hot-atom chemistry have been limited to homogeneous systems because of the short range of the recoil atoms involved. Tritons, however, are exceptional because, unlike other recoil atoms produced in common nuclear reactions, they have a range measured in microns rather than angstroms. Thus the tritons from neutron-bombarded Li^6 have a range of approximately 50 μ ($\sim$5 mg/cm²) in organic materials. This presents the interesting possibility of using heterogeneous systems to study the hot-atom chemistry of tritium and to produce activated molecules. In a reasonably finely divided mixture the tritium created in one phase can recoil out of it and into a neighboring phase, where it can undergo hot-chemical reactions with the production of radioactive molecules. For convenience we may call these processes "heterogeneous hot-atom chemistry" and "heterogeneous recoil tagging." The possibility of using heterogeneous as well as homogeneous systems gives an additional and very important advantage to tritium methods of recoil tagging. While a suitable homogeneous system for irradiation is often difficult to find or hard to prepare, a heterogeneous system is always readily available.

The reaction $Li^6(n,\alpha)T$ is convenient for this purpose because it has a slow neutron cross-section of 910 barns for an isotope occurring in 7.5-percent natural abundance. This yield, together with the shorter half-life of tritium, makes it possible to use conveniently short irradiations.

A mixture of Li_2CO_3 and glucose was chosen to test these ideas. The system for irradiation was prepared by grinding together equal amounts with a pestle and mortar. (The 1-μ particles thus produced were actually much smaller than is necessary.) A preliminary run with a glucose-Li_2CO_3 mixture showed that a significant fraction of the radioactivity followed glucose through paper chromatography.

In a second run a 160-g sample, spread over an area of 200 cm² to minimize self-shadowing, was exposed to a neutron flux of 6×10^9 neutrons/cm² sec. At the end of the 65-hr irradiation the mixture was slightly brownish from radiation decomposition.

Table 1. Counting rates from successive recrystallizations of glucose pentaacetate.

Sample	Weight (mg)	Counts/min	Counts/min mg
GPA-1	7.48	23,000	3080
	5.94	18,700	3150
GPA-2	9.24	28,980	3150
GPA-3	5.86	17,960	3060
GPA-4	6.28	19,690	3140
GPA-5	13.16	41,000	3120

Glucose was separated from Li_2CO_3 by hot water extraction and absorption on Amberlite 120-IR resin. Organic acids were removed on Duolite-A-4 (hydroxide form) resin. The solution was decolorized with Darco 60 charcoal, concentrated to a syrup, diluted with methyl alcohol, reconcentrated and seeded with glucose crystals. After filtration, the precipitate was triturated with methyl alcohol, filtered, washed with methyl alcohol, and dried. The glucose was then converted to glucose pentaacetate and recrystallized five times from ethyl alcohol-water solution. Aliquots from each fraction were counted internally in a Geiger flow counter as infinitely thick solids. Several samples were converted to gas and counted by the technique of Wilzbach, Kaplan, and Brown (*8*). The constant specific activity through five recrystallizations, as shown in Table 1, indicates the absence of radioactive impurities in the glucose pentaacetate.

From the known neutron flux and cross-section values, we conclude that approximately 10 percent of the tritons stopped in the organic phase had been incorporated into glucose in nonlabile positions. Any tritium originally substituted into the hydroxyl positions would have been removed during purification. The specific activity of glucose obtained in this run was 3μc/g of glucose.

In general, the limits of specific activity attainable will depend on the stability of the particular compound toward radiation decomposition. Although glucose appears to be exceptionally susceptible to radiation damage, preliminary results of further experiments indicate that specific activities 100 times greater than that we report are possible. In more favorable cases, irradiations of a few days in fluxes of 10^{12} to 10^{13} neutrons/cm² sec could produce specific activities of the order of millicuries per gram.

L. Kaplan at Argonne National Laboratory has

carried out an independent check of our technique using Li_2SO_4 and benzoic acid. With a precise measurement of the neutron flux it was determined that 25 percent of all the tritons produced resulted in benzoic acid labeled in the ring hydrogens. An activity of 96 μc/g of benzoic acid was obtained with little radiation decomposition (*9*). This experiment demonstrates that the method is applicable to cyclic systems.

From this experimental evidence it would appear that heterogeneous recoil tagging should be generally useful for making tritium-labeled organic compounds of good specific activity. The type of system used in the experiments quoted—a powdered mixture—is by no means the only one that may be used. Presumably a slurry or emulsion containing an organic and a lithiated phase should work provided that the particle size was not much larger than the recoil range.

Although preparation of the labeled material is not difficult, its purification is complicated by radiation damage. Many of the molecules activated by the recoil tritons may be slightly altered by them to produce highly radioactive trace materials, chemically similar to the parent compound. In the purification process, useful quantities of these species may be separated.

An obvious limitation of the technique proposed here is that it cannot produce the very high specific activities obtainable by chemical synthesis or exchange with materials containing large percentages of radioactive atoms. A further and probably more serious drawback is that in general it will not be possible to produce compounds labeled at specific positions. As a first approximation it is to be expected that recoil tritons will produce random labeling. This will also result in some of the tritium being held as labile atoms. However all such loosely bound tracer can be washed out in the purification.

The practical limits of this technique have yet to be ascertained. Since larger molecules are usually more susceptible to damage by radiation, it is quite possible that with high-molecular-weight compounds only low specific activities will be obtainable. Further study is required for a better understanding of the mechanisms involved in these phenomena.

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Charles Manning Child

BY his life and works Charles Manning Child added further distinction to the distinguished New England family name of Manning. He early showed a predilection for the philosophic aspects of biology. After completing the master's degree at Wesleyan University, he went to the University of Leipzig with the intention of studying under Wundt. However, he soon became dissatisfied with the type of study offered and transferred to the zoology department, where he was granted the doctor's degree under Leuckart in 1894. Surprisingly enough, his doctoral research was purely morphological and histological; it was concerned with certain sense organs of the Diptera.

Returning to the United States, Child became a prominent member of that brilliant group of American embryologists who devoted themselves in the 1890's to the subject of cell lineage and produced a series of imperishable articles. Here Child already revealed his trend toward organicism, for he rejected the implications of the mosaic theory of development that had been derived from cell-lineage studies and joined Whitman in his stand against cellular explanations of development.

About 1900 Child began the long series of experiments on the regeneration of coelenterates and flatworms that was to endure through much of his career. He constantly sought for some governing factor in regeneration. At first he believed that this factor was mechanical and ascribed morphogenetic control to such matters as tension, pressure, locomotory activity of the regenerating piece, and the like; reconstitution was believed to result from the attempt of a regenerating piece to function like the whole. On this basis Child published in 1910 a classical article, "The regulatory processes in organisms," in which he pointed out that the continuity of organic individuality is dependent on physiological correlation. This article was the prelude to the emergence of the gradient theory about 1911.

The gradient theory was based on the results of a long accumulation of experiments on the regeneration of planarians. These experiments led Child to abandon his theory of mechanical control of morphogenesis and to concentrate on a physiological gradation of processes as the controlling factor. The essence of the gradient theory is that a gradation of physiological processes forms the basis of polarity and sym-

metry and also controls the regenerative processes.

In 1915 Child published what I consider the most fruitful and outstanding of his books, a small volume entitled *Individuality in Organisms*. The essential thesis of this book is that the problem of the unity of the organism is the problem of correlation, and that correlation is achieved by anteroposterior dominance, which in turn is the expression of an anteroposterior gradation of physiological processes. In this book Child also developed the important concept of physiological isolation or escape from dominance, bringing forward a wealth of facts in support of these concepts.

The year 1915 also saw the publication of the important volume *Senescence and Rejuvenescence*. Later books, *The Origin and Development of the Nervous System* (1921) and *Physiological Foundations of Behavior* (1924), are of lesser value, in my opinion. Finally, in 1941, Child summed up his concepts and the experimental bases for them in the outstanding volume, *Patterns and Problems of Development*, which forms an essential guide to his philosophy of the organism.

Child spent most of his scientific career in a frontal attack on the fundamental biological problem: organization. He saw, as most of his zoological colleagues could not see, that the properties of the organism—its order, its unity, the correlative nature of its activities—cannot be explained by assigning powers to elementary particles, genes, or what not. Particulate theories fail to touch the essential problem, the characteristics of the organic individual, of which the chief one is integration. The problem of organismic integration is one of both pattern and material. Hereditary factors enter into the material, but the main pattern of organisms, the axiate pattern, is explicable as a gradient in the rate of physiological processes. Such axiate pattern is thought of as arising in the last analysis from the differential action of the external world on protoplasm, establishing a gradation.

Following his retirement in 1937 from the University of Chicago (to which he had come in 1895), Child continued, at Stanford University and its marine laboratory, his experimental work on the alteration of development by chemical means, a method he had long used as a means of analysis of the role of gradients in development. He was still pursuing this line of investigation at the time of his death.

Throughout his scientific career Child was notable for his whole-hearted devotion to fundamental problems of biology. He was entirely devoid of the personal ambition, the seeking for advancement, position, and fame, that mars the lives of many scientists. He ever adhered to the highest standards of scientific integrity and thereby won the respect of all who knew him. He was a great lover of the outdoors, especially of mountainous country, and throughout his life was wont to take the trail in the western mountains with his pack and photographic equipment, for he greatly enjoyed photographing scenes of natural beauty. He lived a good life, employing his mental faculties to their utmost in research and enriching himself by contact with unspoiled nature.

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News and Notes

Research on Semiconductors

Approximately 450 scientists from 20 countries met in Amsterdam, 29 June–3 July 1954, to discuss the latest results in semiconductor research. This second international conference on semiconductors (the first one was held at Reading, England, in June 1950) was organized by the Netherlands Physical Society and supported by the International Union of Pure and Applied Physics and UNESCO. The conference committee, headed by E. J. W. Verwey with H. J. Vink as secretary, was responsible for the extremely successful organization of the conference. A total of 65 papers was presented. The program was arranged to provide adequate time for formal and informal discussions and to give room for spontaneous reaction to the papers.

An introductory paper outlined the present scope of semiconductor research, and the conference closed with a lecture summarizing the papers presented. Although considerable interest was expressed in the various intermetallic semiconductors and the sulfides, selenides, and tellurides of lead and cadmium, the scope of the papers indicated continued emphasis on the elementary semiconductors, germanium and silicon.

The introductory lecture by H. B. G. Casimir (Eindhoven) gave a broad perspective of the problems in semiconductor research. The problems were classified into four main divisions: (i) stationary states, that is, energy band structure of the periodic crystal lattice, including surface and impurity states; (ii) transport phenomena, such as conduction, Hall effect, thermoelectric power; (iii) transition phenomena, which dealt with transitions between stationary states; and (iv) recombination phenomena, which dealt with problems conducted with carrier generation and recombination.

There were some papers that presented theoretical calculations with regard to the structure of energy bands. Among these was the paper of F. Hermann (R.C.A., Princeton, N. J.) on diamond and germanium which gave an interesting insight into the nature of the band structure in this type of lattice. Results, using cyclotron resonance, were reported by A. F.

Kip (University of California), B. Lax *et al.* (Project Lincoln, M.I.T.), and C. Kittel (University of California). Important information was obtained on the energy band structure of germanium and silicon. These results, in conjunction with newly introduced methods, as well as magnetoresistance and infrared absorption measurements, show that, for these two important semiconductors, the electrons, as well as the holes, cannot be characterized by a single effective mass. Investigation of the band structure of alkali chlorides by x-ray spectroscopy was reported by L. G. Parratt (Cornell Uninversity), revealing a narrow $1s$-$3p$ emission in KCl that could not be correlated with the $3p$ valence band. L. Pincherle (R.R.E.) discussed the theoretical determination of electronic band structure of polyatomic crystals.

Various effects associated with surface states were discussed by J. Bardeen (University of Illinois), and results of investigations on germanium, from which the properties of the surface states had been deduced, were presented. Studies of surface properties of germanium by the method of half-cell potential in an electrolyte were reported by W. H. Brattain (Bell Telephone Laboratories). Impurity energy levels in germanium and silicon were discussed by J. A. Burton (Bell Telephone Laboratories).

Transport phenomena—conductivity and galvanomagnetic effects—were the subjects of a number of papers. The effect of nonspherical energy surfaces was considered. Thermal conductivity was also discussed, and evidence of electron contribution to thermal conductivity in InSb at high temperatures was presented by G. Busch (Zürich). Conduction in the impurity bands of a semiconductor was discussed, based upon results of conductivity and Hall effect measurements on germanium at temperatures down to 1°K (H. Fritzsche and K. Lark-Horovitz, Purdue University). Similar results were reported for CdS by F. A. Kröger (Eindhoven). P. Aigrain (Paris University) presented a theoretical attempt to treat impurity band conduction.

Investigations of electron-hole recombination and minority carrier trapping at low temperatures in germanium, emphasizing the effect of localized energy states associated with lattice defects and impurities, were reported by H. Y. Fan (Purdue University). Luminescence and photoconductivity connected with excitation and trapping of carriers were discussed by M. Schoen (Mosbach/Baden) for sulfide-type materials. Observations on the surface recombination of carriers in germanium were presented in several other papers.

The intermetallic semiconducting compounds received considerable attention. H. Welker (Siemens-Schukertwerke, Erlangen) surveyed the properties of a large number of these materials, including combinations of groups II–IV, II–V, III–VI, and V–VI elements, emphasizing III–V compounds. An explanation for the large electron to hole mobility ratio was mentioned, which is based on a one-dimensional Kronig model with alternate deep and shallow potential wells (Seraphin). From a device standpoint, GaAs was reported to make a good high-voltage rectifier up to 250 v with good photosensitivity.

More complicated intermetallic compounds were discussed by C. H. L. Goodman and R. W. Douglas (G. E., Wembley). These compounds included ternary compounds of the formula ABX_2 where A = Cu, Ag; B = Al, Ga, In, Tl; and X = S, Se, Te, and quaternary compounds, such as Cu_2FeSnS_4. Some of these materials gave high back voltage rectifiers of more than 100 v.

There were many contributions to the study of polar semiconductors of the PbS, CdS, ZnS types. Some of these provide excellent examples of the coordination of chemical and physical research. H. J. Vink (Eindhoven) and W. W. Scanlon (U.S. Naval Ordnance Laboratory), on CdS and PbS crystals, respectively, showed how the electric properties of these semiconductors could be controlled at will by heat treatments in the vapor phase of the crystal. A survey of some of the electric and optical properties of the lead compounds was given by R. A. Smith (R.R.E.), in which some of the difficulties of evaluating the energy gap were reviewed.

Silver halides, which possess many properties intermediate between ideal ionic crystals, such as the alkali halides and valence semiconductors, such as Ge and Si, were surveyed by F. Seitz (University of Illinois). The effects of excitons were discussed.

The final paper by D. Polder (Bristol) summarized the results of the conference. An effort was also made to develop a band structure representation of a semiconductor from consideration of different types of bonding and antibonding orbitals.

The proceedings of the conference, including most of the invited and contributed papers, were published in a special issue of *Physica* (Nov. 1954).

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Science News

In 1954 the member societies of the **American Institute of Biological Sciences** voted to have the institute become independent of the National Research Council, under which it had functioned since it was formed in 1948. Then last January the institute became incorporated in the District of Columbia as a nonprofit, national organization of professional biological societies and biologists. New office space was secured at 2000 P St. NW, Washington 6, D.C., and in March the staff moved. These offices are on the 5th floor of a newly remodelled building just off Dupont Circle; visitors are cordially invited to see the new quarters.

Hiden T. Cox, professor of botany at Virginia Polytechnic Institute and deputy director of A.I.B.S. for the year 1953–54, has agreed to return on a permanent basis as director of the institute. He will take office on 1 July.

Formation of a **National Health Council Committee on Research Administration** was approved at a meeting of the council's executive committee on 26 Apr. Morton D. Schweitzer, scientific director of the Muscular Dystrophy Associations of America, was named its first chairman. Hugh R. Leavell, president of N.H.C. and head of the department of public health practice of the Harvard School of Public Health, said of the new committee:

> The growing volume of research activities which voluntary agencies carry on makes it imperative that we set up such a Committee. It is particularly important for the voluntary agencies to develop comprehensive facts about what they are doing, now that the Hoover Commission has proposed establishment of a Federal Council of Health to facilitate the health research program of the Federal Government. We should be in a position to collaborate with this Federal Council if or when it is organized.

At a meeting on 11 May, the committee exchanged views on such matters as range of stipends, budgeting, block grants versus project grants, and procedures of reporting to the supporting agency, other health groups, and the public. In addition to Schweitzer, members of the committee are key representatives from 10 national organizations concerned with diabetes, heart, nurses, arthritis and rheumatism, crippled children, infantile paralysis, multiple sclerosis, blindness, tuberculosis, and cerebral palsy.

Children ask more **questions about science** than any other subject, according to a nationwide survey conducted by the University of Illinois. The survey included 6313 pupils in grades 4 through 8, 4531 parents, 212 teachers, and 169 librarians. It was directed by J. Harlan Shores, professor of education. He found questions about science running two to one ahead of questions about other school subjects. At the library, grade-school children are looking up information about science more than information on any other field, and in reading choices, science subjects are among the top three fields. Shores has reported that the survey findings indicate that science needs are not being fully met and that the interest in the subject shown by grade-school pupils is not being fully exploited.

Fence lizards harbor a parasite that has been discovered by Jim Bonorris and Gordon Ball, zoologists at the University of California in Los Angeles. The **newly identified reptilian parasite,** *Schellackia occidentalis,* has an interesting life cycle.

It reproduces in the intestine of the lizard. After going through several stages, it moves into a red blood cell. Then the only way it can get into another lizard is by means of the bite of a bloodsucking animal on the outside of the lizard. Mites which infest the lizard accommodate the organism in this respect, for they suck up blood containing the parasite. Eventually the tongue of another lizard plucks the mite off the back of the first reptile, and the mite-borne parasite is conveyed to its intestinal spawning grounds.

The United States will build a swimming pool **reactor in Geneva,** Switzerland, for demonstration at the United Nations International Conference on the Peaceful Uses of Atomic Energy. The exhibit will enable visiting scientists and technicians to observe a reactor that provides excellent facilities for a variety of cross-section measurements and experiments with neutrons and gamma rays, including shielding studies and production of radioisotopes. Qualified persons will be allowed to operate the machine. The project for the Geneva conference will be carried out by Oak Ridge National Laboratory, which is operated for the AEC by the Carbide and Carbon Chemicals Co.

A 23.2 percent success has been achieved by clinics helping **childless couples** to have children. Among 13,051 couples studied and treated in 21 clinics during a period of 28 years, 3026 pregnancies occurred. These results were reported by Mary Steichen Calderone, medical director of the Planned Parenthood Federation of America, New York, at the recent meeting of the American Academy of General Practice.

In a report published in the May issue of the *Journal of the American Dental Association,* the association's Council on Dental Research recommends that the use of **ultrasonic dental instruments** be withheld until their practicability and safety are proved by extensive investigation. An editorial in the same issue of the *Journal* sharply criticizes the promotion of ultrasonic devices by an equipment manufacturer.

When he delivered the 1955 Arthur Dehon Little memorial lecture at the Massachusetts Institute of Technology last month, Charles A. Thomas of St. Louis, president of Monsanto Chemical Co., urged the removal of the **barriers that separate pure scientists** from applied scientists. In his talk on "Creativity and science," he envisioned a union of theorists and technologists in this country out of which will come the most flourishing, vigorous growth of creativity in all history. He urged that

> From undergraduate training upward—and it cannot be started too early—students of the sciences should be made to appreciate that some men are driven by a deep desire to add to the store of knowledge, that the challenge of discovery is rewarding whether it has immediate practical value or not . . . [that] whatever path the science student chooses . . . he must be conditioned to realize that his choice is made on the basis of personal preference, with the firm conviction that neither the one nor the other is a superior calling.

K. Alvin Merendino, professor of surgery at the University of Washington, Seattle, told the recent American Surgical Association meeting that intestinal sections have been used successfully to replace diseased esophaguses in 10 patients. In the new surgical technique, a part of the **intestine is transplanted** at the junction of the lower esophagus and the stomach as a substitute for the sphincter.

The operation has been used only on patients upon

whom all conventional methods have failed. The studies were supported by Initiative 171 funds and by the U.S. Public Health Service. Merendino was assisted in the research by David H. Dillard, a research fellow at King County Hospital.

Scientific notes, papers, and letters of the late **Enrico Fermi** have been given to the University of Chicago Library by his widow, Laura Fermi. Awards and medals given Prof. Fermi in recognition of his work on the atomic bomb and other scientific achievements, notebooks in which he recorded his theories and experimental data, manuscripts of many of his published papers, and correspondence with important scientists in the United States and Europe are included in the collection.

It is probable that the first **synthetic diamonds** were those produced in February 1953 by the Swedish ASEA electric company in Västerås, which began its work with artificial gems in 1942. The earliest Swedish diamonds were no bigger than grains, but their genuineness was established by means of x-rays and the synthesis experiments have been repeated many times with excellent results.

Scientists in the News

George K. Batchelor of Cambridge University, an authority on turbulence and a pioneer in the new science of magnetohydrodynamics, is spending a 3-mo period, which began 8 May, at Cornell University. A senior lecturer in mathematics at Cambridge, he is taking part in two Government-sponsored research projects in the Cornell College of Engineering: the ionosphere project, sponsored by the Army Signal Corps, and the project on propagation of expansion and compression waves, sponsored by the Office of Naval Research.

K. S. Krishnan, president of the National Academy of Sciences of India, was honored at the annual dinner meeting of the National Academy of Sciences (U.S). Krishnan occupies or has occupied the highest honorary posts in Indian science, including the presidencies of the National Institute of Sciences and the Indian Science Congress Association. His eminence has been recognized in England also, where he was elected a fellow of the Royal Society in 1940 and was knighted in 1946. He is director of the National Physical Laboratory at New Delhi and a member of the Indian Atomic Energy Commission. Krishnan was a special guest of the academy during the 3 days of its recent meeting in Washington.

In addition to presenting a paper on "Thermionic constants determined by a new method" at one of the scientific sessions, he gave a dinner address. In this talk he pointed out that in India science has been most valued as a liberalizing force in culture. Because the development of science is more recent in India than in Western countries, he said that its applications through technology are only now beginning to have significant impact on the life and economy of India. He paid high tribute to the contributions of American science and the sciences of other Western countries to the growth of science in India and to the furtherance of human welfare there. He referred to the value of the wide use of the English language as a means of communicating scientific ideas, and related this to the unique contributions of different cultures to the growth of a common understanding among peoples.

Other speakers at the academy dinner included **Harold Spencer Jones,** Astronomer Royal of Great Britain, and **Charles Greeley Abbot,** former secretary of the Smithsonian Institution, who was celebrating the 40th anniversary of his election to the academy.

Establishment of a scholarship fund in memory of the late **Henry K. Benson,** a member of the University of Washington faculty for 50 years, has been approved by the university board of regents. Dr. Benson, a professor of chemistry and chemical engineering, joined the university in 1904, and headed the department of chemistry and chemical engineering from 1920 until his retirement in 1947. He died last September.

The memorial was created by Mrs. Benson with a gift of $1000, and this sum will be set aside as the core of a fund into which the university will place other contributions from former students and friends of Dr. Benson. Income from the growing fund will be used to aid outstanding students in chemistry and chemical engineering, and it is hoped that the first award may be made for the 1955–56 school year.

Marvin D. Whitehead, formerly of the department of plant pathology, A. and M. College of Texas, became associate professor of field crop pathology in the department of field crops, University of Missouri, on 1 Apr.

Brig. Gen. James P. Cooney has been named to succeed Maj. Gen. Silas B. Hays, the new Surgeon General, as Deputy Surgeon General of the Army. Cooney has achieved distinction as one of the Army's outstanding authorities on radiology and the medical effects of atomic explosions.

The 20th annual **Leo Loeb** lecture, sponsored by Mu chapter of Phi Beta Pi medical fraternity of Washington University School of Medicine, St. Louis, Mo., was delivered on 12 Apr. by **Tinsley R. Harrison,** professor of medicine and head of the department at the Medical College of Alabama. Loeb, in whose honor the annual lecture is given, is professor emeritus of pathology. He is well known for his work on cancer.

Otto Oldenberg, a pioneer in the teaching of atomic physics, will retire this summer as professor of physics at Harvard University. As emeritus professor of physics, Oldenberg will continue experimental research at Harvard, research that is supported by the Office of Naval Research and the Air Force Cambridge Research Center. Oldenberg's advanced labora-

tory course in atomic physics, which was initiated at Harvard in 1931, was one of the first such courses to be given at an American or European university. He is the author of a standard college textbook, *Introduction to Atomic Physics*, the second edition of which was published in 1954.

His major research has been concerned with the kinetics of chemical reactions in gases. He used the absorption spectrum as a test for free radicals—particles that by their chemical instability rapidly disappear. Later his interest turned to fundamental processes in gases, for he wished to explain phenomena in the upper atmosphere such as the aurora and the weak radiation emitted from the upper atmosphere of the earth that is observed as the light of the night sky.

Oldenberg was born in Berlin, Germany, in 1888. He received his undergraduate education at the universities of Heidelberg, Göttingen, and Munich; the Ph.D. at the University of Göttingen in 1913, and the M.A. from Harvard University in 1942. For many years he was associated with the University of Göttingen. He joined the Harvard staff as a lecturer in 1929 and was appointed professor of physics in 1930.

The memory of the late **Brig. Gen. James Stevens Simmons,** MC, USA (Ret.), was honored on 21 Apr. by a memorial lecture delivered at Walter Reed Army Medical Center by **John H. Dingle,** professor of preventive medicine at Western Reserve University School of Medicine. In the future the lecture will be known as the James Stevens Simmons Memorial Lecture; it is to be given annually on a subject pertaining to preventive medicine. Simmons retired in 1946 after 30 years of service in the Army Medical Corps. At the time of his death on 31 July 1954 he was dean and professor at the Harvard School of Public Health.

Loren C. Petry, professor of botany at Cornell University for more than 30 years, will retire on 30 June. He is a faculty member of both the College of Agriculture and the College of Arts and Sciences; and for 10 years, beginning in 1934, he directed Cornell's Summer Session, reorganizing and coordinating what originally were four separate units. During World War II he guided the basic course of the Army Specialized Training Program at Cornell, and in June 1944, he resigned his summer-session post to become director of veterans' education. At the program's beginning, there were only about a dozen veterans attending Cornell under G.I. benefits, but by the fall of 1947 there were 5200, and when he resigned in 1948 to give full time to teaching and research there were 4800.

In 1952 Petry received the "Outstanding Professor" award from the senior class of the College of Agriculture. His enthusiastic students maintain that he leaves them with "a lasting understanding of the basic how's and why's of the plant world." Believing in teaching ways of learning instead of subject matter alone, Petry changed his botany instruction in 1938 to emphasize laboratory work over lectures. With E. M. Palmquist, then at Cornell, he published a laboratory manual embodying this method. During the 1955–56 academic year, after a 6-wk vacation abroad, he will go to the University of Missouri to assume the teaching post of Dr. Palmquist, who will be on leave.

Petry, whose research has been in paleobotany, leaves Cornell one of the best collections of Devonian plants in America. It was as a result of his enthusiasm that paleobotany was introduced at Cornell in 1925 as a subject for graduate study. Petry's nonprofessional interests are mountain climbing, sailing, and gliding.

As a youth Petry did not plan to study botany. In 1907 he received a B.S. in civil engineering and mathematics from Earlham College, and in 1908 a B.S. from Haverford College, where he is now a member of the corporation. Returning to Ohio, the state where he was born in 1887, he taught science in the Urbana high school for 2 years; this stimulated his interest in botany. In 1911 he received his M.S. in botany from the University of Chicago, and in 1913 his Ph.D. He became an instructor at Syracuse University in 1914, and left his position there to go to Cornell.

Cecil E. Boord, research professor emeritus of the department of chemistry at Ohio State University, will receive the university's Joseph Sullivant medal on 10 June. This award, which is presented only once every 5 years, is given in recognition of an "admittedly notable achievement" in the arts or sciences by an alumnus, a former student, or a faculty member of the university. Boord is being honored for his long years of pioneering research in the synthesis and testing of the hydrocarbon components of gasoline.

Last month Pope Pius XII announced 14 appointments to the **Pontifical Academy of Science,** which raised the number of academicians to 66: Theodore von Kármán, director of the Guggenheim Aeronautical Laboratory of California Institute of Technology; Charles Herbert Best, professor of physiology at the University of Toronto; Paul Niehans, Swiss gerontologist, member of the senate of the University of Tübingen, and the Pontifical physician; Hermann Alexander Drueck, director of the Dublin Astronomical Observatory; Louis de Broglie, professor of theoretical physics at the University of Paris, perpetual secretary of the Academy of Science of the Institute of France, and Nobel prize winner; Julio Cesar Garcia Otero, professor of medical pathology at the University of Montevideo; Otto Hahn, president of the Max Planck Institute and Nobel prize winner in chemistry; Werner Carl Heisenberg, professor of theoretical physics at the University of Göttingen and Nobel prize winner; Walter Rudolph Hess, professor of physiology at the University of Zurich and Nobel prize winner in medicine; Gaston Maurice Julia, professor of mathematics at the Sorbonne and the Polytechnic Institute of Paris; Arne Tiselius, professor of biochemistry and director of the Bio-

chemical Institute at the University of Uppsala; Artturi Ilmari Virtanen, professor of chemistry at the University of Helsinki, president of the Academy of Finland and Nobel prize winner in chemistry; Max von Laue, professor of physics at the University of Göttingen and Nobel prize winner; and Hermann Weyl, professor of analysis and higher mechanics at the University of Zurich.

Edward M. Weyer, Jr., editor of *Natural History,* received the annual award of the National Life Conservation Society during a recent meeting at the American Museum of Natural History, New York. He received a scroll citing his 20-year tenure as editor of the magazine.

A. G. Norman, who has been on the University of Michigan faculty as a research botanist for the Michigan Memorial Phoenix Project No. 32, and as a professor of botany, without tenure, in the College of Literature, Science and the Arts, has been appointed director of the Botanical Gardens and professor of botany, with tenure. He will succeed **H. H. Bartlett** when the latter retires on 1 July.

Howard A. Rusk, professor and chairman, and **Eugene J. Taylor,** assistant professor, department of physical medicine and rehabilitation, New York University College of Medicine, were recently awarded the Order of Merit José Fernandez Madrid by the Government of Colombia. This is the highest health award given by the armed forces of Colombia and was bestowed for "distinguished service for the military health of Colombia." Rusk and Taylor, with Captain Thomas Canty, U.S. Navy Hospital, Oakland, Calif., recently visited Colombia, where they conducted clinics, lectures, and demonstrations, and acted as consultants for the new 850-bed military hospital being erected in Bogotá.

Leslie G. Smith, English geophysicist with the U.S. Air Force Cambridge Research Center, has been awarded the 1954 Darton prize by the Royal Meteorological Society of London for his paper, "An electric field meter of extended frequency range," which was published recently in the *Review of Scientific Instruments.* The article describes a meter developed by Smith to measure the recovery of field strength under a thundercloud after the occurrence of a lightning stroke. Recovery times are measured in fractions of a second, and no field meter was previously available which would measure in the order of a thousandth of a second.

This summer Smith will return to Florida, where he first conducted his thunderstorm electricity experiments. He will establish a ground network of field meters in the vicinity of Orlando, utilizing a large area to intercept as many thunderstorms passing over the region as possible. He will be joined by **Christos Stergis,** another thunderstorm specialist, who will fly large constant-level balloons above the thunderstorms to measure the field strength and charge density on top of thunderclouds. Data measured by the balloon equipment will be transmitted to the ground by means of a radio link.

Smith and Stergis are part of a small team of scientists from the Air Force Cambridge Research Center who are conducting intensive studies of thunderstorms and lightning in the interest of the operational safety of modern military aircraft.

Levie van Dam has been appointed associate curator of ichthyology by the Academy of Natural Sciences of Philadelphia. He will make preliminary studies for the new aquarium to be built by the Fairmount Park Commission. These studies will enable the academy to perform the needed advisory service while the new aquarium is being planned, built, stocked, and added to the educational facilities and public buildings at Fairmount Park. At present Van Dam is conducting fish research at the Oceanographic Institution, Woods Hole, Mass.

The following appointments to assistant professor have been announced. Catholic University: **Gottfried O. Lang,** anthropology. University of Utah: **Russell M. Nelson,** surgery.

Meetings

The 1955 **Conference on Nuclear Chemistry** of the AAAS Gordon Research Conferences will take place in Meriden, N.H., 27 June–1 July. Chairman and vice chairman are Anthony Turkevich of the University of Chicago and Leo Yaffe of McGill University. For further information on the Gordon Conferences, see *Science* **121**, 571 (22 Apr. 1955).

27 June, Theoretical aspects of nuclear chemistry, A. Turkevich, *discussion leader*: P. Morrison, "Nuclear models"; G. Breit, "Remarks on the theory of nuclear reactions induced by heavy ions"; J. D. Jackson, "A schematic model for (p, xn) and spallation reactions in heavy elements." *Nuclear reactions at energies below 100 Mev,* G. Friedlander, *discussion leader*: J. W. Cobble, "Fission-spallation competition at low energies"; R. M. Diamond, "Production of isomers and excitation functions below 100 Mev."

28 June, Nuclear reactions induced by heavy ions, G. Breit, *discussion leader*: W. Forsling (title to be announced); K. Chackett (title to be announced); H. L. Reynolds, "Excitation functions for nitrogen induced reactions"; a representative of the University of California, "Heavy ion bombardment work and plans at Berkeley"; G. Breit, "Yale plans for a heavy ion accelerator." *Nuclear reactions in the Bev region,* N. Sugarman, *discussion leader*: K. Chackett, "Spallation products formed in light elements with protons of energy up to 0.95 Bev"; G. Friedlander, "Radiochemical studies at the cosmotron"; E. Hyde, "Radiochemical studies at the bevatron."

29 June, Nuclear fission I, L. Yaffe, *discussion leader*: G. T. Seaborg, "Spontaneous fission"; E. P. Steinberg, "Fission yields and fine structure by mass spectrometry"; R. H. Tomlinson, "Thermal neutron fission yields in U^{235}"; S. Thulin, "Rare gas fission products"; D. O'Kelley, "Short-lived fission products." *Nuclear fission II,* L. Glendenin, *discussion leader*: J. S. Gilmore, "Fission studies at Los Alamos"; B. L. Cohen, "Angular distribution of fission fragments"; R. L. Wolke, "Angular distribution

of fission fragments from the high energy proton bombardment of bismuth"; R. A. Schmitt, "Fission asymmetry as a function of excitation"; L. Katz, "Photo-fission studies."

30 June, Neutrino experiments: F. Reines and C. Cowan, "Status of Los Alamos neutrino experiment"; R. Davis, "Status of Brookhaven neutrino experiment"; J. M. Robson, "Angular correlation in neutron decay." *Positronium*, M. Deutsch, *discussion leader*: M. Deutsch (title to be announced); R. E. Bell (title to be announced).

1 July, Radiochemical separations, E. Hyde, *discussion leader*: K. Kraus, "Anion exchange column separations"; R. Prestwood, "Radiochemical separation methods at Los Alamos"; B. G. Harvey, "Ion exchange separation methods applied to heavy elements."

The 7th **International Congress of Comparative Pathology** will be held at the Institut d'Anatomie Pathologique, Lausanne, Switzerland, 26–31 May. The program will include, in part, formal papers and discussions on viral infections transmitted to man by animals; pathologic and hygienic aspects of atmospheric pollution problems; and growth disturbances in comparative pathology, including the human problem. Requests for the program and inquiries concerning registration should be addressed to the Chairman of the U.S. Section, Lee M. Hutchins, Chief, Division of Forest Disease Research, U.S. Forest Service, Washington 25, D.C.

The 2nd **International Powder Metallurgical Congress** will take place in Reutte, Tyrol, Austria, 20–23 June. Its sponsor, Paul Schwarzkopf, president of American Electro Metal Corp., Yonkers, N.Y., and owner of the Metallwerk Plansee in Reutte, has announced that the topic will be "High temperature and corrosion-resistant materials by powder metallurgy." Approximately 300 representatives from 17 nations have been registered as delegates, and among them are 36 U.S. scientists, industrialists, and engineers.

A conference on **Nutrition in Infections** will be held at the Barbizon-Plaza Hotel, New York, under the auspices of the New York Academy of Sciences, 24–25 May. Some 17 U.S. participants and Joachim Kühnau of the University of Hamburg, Germany, and Ruben Lopez-Toca of the University of Havana Medical School, Cuba, will deliver papers covering the role of nutrition in the prophylaxis and treatment of disease, experimental deficiencies, effects of vitamins and antibiotics, and so forth.

W. A. Wright, medical director of the Pfizer Laboratories division of Chas. Pfizer and Co., New York, is conference chairman, and session chairmen are Norman H. Jolliffe, director of the bureau of nutrition, Department of Health, New York City, and Henry Welch, director of the Division of Antibiotics, U.S. Food and Drug Administration, Washington, D.C. An understanding of the exact role of nutrition in the maintenance of health and in the prevention and treatment of disease, and the voluminous data concerning the interrelations between antibiotics and nutrition in various infections, are important data to be dealt with during this conference.

At the annual Washington (D.C.) meeting of the **American Physical Society** 28–30 Apr., a large attendance heard 394 contributed papers and 27 invited papers. Four sessions dealt with new results in meson physics. The discovery that heavy kappa mesons can be produced by the bevatron and the cosmotron makes possible a detailed study of these particles comparable with recent research on pi and mu mesons. This may reduce the confusing complexity of heavy-meson phenomena.

In an invited paper on the new transuranium elements, A. Ghiorso announced the discovery of element 101, named mendelevium by him and the other members of Seaborg's staff at the University of California. This isotope of mass 256 was formed by bombarding element 99 with alpha particles. Seventeen atoms of 101 decayed with a half-life of the order of 1 hr. With increasing atomic weight, the half-life for fission decreases much more rapidly than that for alpha emission, and for element 101 the two are of the same magnitude.

A symposium honoring the memory of Enrico Fermi was an impressive event that drew a capacity audience. H. A. Bethe was chairman, and F. Seitz, E. Konopinski, E. Segrè, W. H. Zinn, and H. L. Anderson discussed five fields in which Fermi made outstanding contributions: Fermi statistics, beta decay, neutron physics, atomic energy, and mesons.

A **Health Physics Conference**, devoted to radiation safety, will be held 13–15 June at Ohio State University. Topics on the program include radioactive waste disposal, air sampling, dosimetry, health physics instrumentation, legislation, reactor safeguards, and other specialized subjects. The meeting is intended to bridge a gap between the theory of radiation safety and its practice in the field in the last few years. Information may be obtained from Francis J. Bradley, Office of Radiation Safety, Ohio State University, Columbus 10.

A **Symposium on the Chemistry of Natural Products** will take place at the Israel Institute of Technology, Haifa, 28–29 June. Participants from the United States and the United Kingdom will be D. H. R. Barton, University of London; C. Djerassi, Wayne University; S. M. Kupchan, Harvard University; R. A. Raphael, Queen's University of Belfast; and G. Stork, Columbia University.

The 28th annual scientific session of the **American Heart Association** will be held on 22–24 Oct. at the Jung Hotel, New Orleans, La. Meetings sponsored by the Council on Community Service and Education and the Council on Rheumatic Fever and Congenital Heart Disease will be held 23–24 Oct. The assembly panels will follow the scientific sessions on 25 Oct. and the general assembly will take place on the morning of 26 Oct.

Those who wish to present a paper should submit an abstract, not exceeding 300 words, in duplicate, to the Medical Director, American Heart Association, 44 E. 23rd St., New York 10, *not later than 1 July*.

Education

A special **workshop in the teaching of astronomy** is being offered in the Cornell University Summer Session by R. William Shaw of the department of astronomy. The course will include an analysis of astronomy in science education with a view to strengthening its effectiveness as a preparation for the appreciation and solution of intellectual and practical problems arising from man's conquest of space. The material will be of special interest to teachers of secondary-school science, to college teachers of introductory astronomy, and to civic group leaders. Objectives are (i) a consideration of curriculum content for high-school, college, and civic groups; (ii) a review of subject matter with emphasis on teaching techniques; (iii) a study of methods and materials for demonstrations, model construction, group projects, celestial observation, and sources of supply. In addition, a limited number of students may construct, under supervision in the department's optical shop, the optical elements for their own reflecting telescopes. Inquiries may be addressed to Prof. R. William Shaw, Department of Astronomy, Cornell University, Ithaca, N.Y.

Michigan State College in East Lansing has been redesignated as **Michigan State University** by the State Legislature. However, the University of Michigan at Ann Arbor may challenge the constitutionality of the change.

More than $7 million has been donated for the **Albert Einstein College of Medicine** of Yeshiva University according to an announcement by the society of the founders of the college. The society is composed of 137 persons who have contributed $25,000 or more to the $10-million building program. The school, nearing completion at Eastchester Rd. and Morris Park Ave. in the Bronx, New York, will admit its first class next September.

Graduate medical training grants of $126,000 have been awarded to the **University of Pennsylvania Graduate School of Medicine** for a 2-year period by the National Institute of Neurological Diseases and Blindness to initiate a unique program of training teachers and investigators in neurology and ophthalmology. Julius H. Comroe, Jr., professor of physiology and pharmacology, will be the program director.

The new course, to begin in the fall of 1955, will be the first of its kind in this country. It will be designed for neurologists and ophthalmologists who have decided to enter or continue a full-time academic career in teaching and research in these specialties. Prospective candidates either must be certified by the American Board of Neurology or the American Board of Ophthalmology or must have all or most of the requirements for Board certification. Preference will be given to men who have been selected by their own medical school faculties for advanced training, with the understanding that after the academic year at Pennsylvania they will return to their own departments to do full-time teaching and investigative work as a career.

Probably not more than five neurologists and five ophthalmologists will be accepted during the first year; it is hoped that the majority of these will be able to obtain partial fellowship support during the training period. One or two internists or surgeons may be accepted during the first year in order to determine the effectiveness of the new program in training medical teachers and investigators in general.

An important part of this new course will be instruction in the art and technique of teaching. This will be accomplished largely by practical work. Initially, the group technique will be utilized in which each member of a small group is in turn the lecturer while the remainder of the group serves as a critical audience. Each lecture will be recorded so that the lecturer will have the benefit of both the playback and audience reaction [see *J. Medical Education* **29**, 39 (1954)]. Recordings will be kept and compared with later performances, in order to gage progress. Later, the "students" will be given active teaching responsibilities, under supervision. Since teaching involves more than lecturing to large groups, there will also be considerable practice in conference, seminar, and ward-round types of instruction. No attempt will be made to achieve uniformity in teaching; the emphasis will be upon improvement in those techniques best suited to the personal attributes of each physician. In addition, attention will be paid to the use of visual aids, the proper design of examinations, and appropriate faculty-student relationships. Special seminars on medical writing and library utilization will be given. The men will also be given broad training in the basic medical sciences of physiology, pharmacology, biochemistry, anatomy, pathology, and microbiology, with particular emphasis on their relation to clinical problems.

Another feature of the course will be a training program designed to provide a good scientific background for medical research. The faculty realizes that it cannot create investigators by didactic courses; however, it believes that it can provide an opportunity for advanced learning that would be very difficult to obtain through existing means. Among the new courses to be created especially for this group are (i) mathematics for physicians engaged in medical research; (ii) statistics and the design of experiments; (iii) recent advances in electronics, chemistry, and physics; (iv) techniques of investigation and their critical analysis; (v) seminars on critical evaluation of medical literature; and (vi) philosophy of research.

Since many of the trainees may eventually become departmental chairmen, special seminars will also be offered on medical administration (including budgeting, personnel selection, hospital administration, and voluntary health plans).

The courses will be given by outstanding teachers, clinicians, scientists, editors, and educators, many of whom will be from universities outside the Philadelphia area. Although it is anticipated that stu-

dents in this course will already be well qualified clinically, courses in the present program of the Graduate School of Medicine may be taken by the group as elective courses. In addition, an opportunity will be offered for investigative work. The course work, coupled with research, will be acceptable as credit for the degree of doctor of science (med.). Address inquiries to Dr. J. H. Comroe, Jr., Graduate School of Medicine, University of Pennsylvania, Philadelphia 4, Pa.

Grants, Fellowships, and Awards

The **Monsanto Chemical Co.** has announced an expanded program of financial **aid to scientific education** during 1955–56. A total of 53 American colleges and universities will benefit from 72 awards, an increase of 9 in the number of schools aided and an increase of 15 in the number of awards granted. The allocations for the coming year include 16 fellowships, 31 undergraduate scholarships, and 25 cash grants that may be used at the schools' discretion to finance research, purchase equipment, or further any other scientific purpose.

These awards are but one phase of Monsanto's overall program of cooperation with scientific education. The company's operating divisions supplement the corporate program with numerous grants for specific research, through faculty and student trainee programs, and by the donation of equipment and materials to schools. The company also makes grants to educational projects of the National Science Teachers Association, the American Institute of Chemical Engineers, and the American Chemical Society.

The City of New York has established **Jonas E. Salk scholarships** of $3500 each to be awarded annually to two outstanding seniors in each of its four colleges. The grants will be for postgraduate study in medical science.

The National Research Council of Canada has granted 267 scholarships for 1955–56, with a total value of $336,300. These scholarships include 62 bursaries worth $800 each, 133 studentships worth $1100 each, and 18 fellowships worth $1400 each. All of these are to be held in Canada.

Special scholarships awarded for study abroad include 33 awards worth $1900 each. These special scholarships are to be held in the following countries: 11 in the United States, 19 in the United Kingdom, 1 in France, 1 in Sweden, and 1 in Denmark.

Twenty-one overseas postdoctorate fellowships at $2500 each have been granted for work in the following countries: 15 in the United Kingdom, 1 in Sweden, 1 in Denmark, 1 in France, 2 in the Netherlands, and 1 in Belgium.

A $45,000 grant has been received from the **Wieboldt Foundation** of Chicago by Northwestern University's school of speech for the establishment of an institute for language disorders in children. Helmer R. Myklebust, Northwestern professor of audiology, has been named director of the new institute. Since 1950 he has been director of the children's hearing and aphasia clinic, of which the institute is an outgrowth. The institute will study language disorders resulting from deafness, brain injury, and emotional disturbances. Primary emphasis will be given to children more than 2 years old who have not yet completed their early school years.

The **Link Foundation,** a trust founded to advance training and education in aeronautics, has recently awarded grants to Ohio State University and to Tufts College, for the establishment of two fellowships in, respectively, aviation medicine and aviation psychology.

Miscellaneous

A traveling **exhibit of medical art** entitled "Ars Medica," comprising works by Rembrandt, Daumier, Hogarth, Toulouse-Lautrec, and others, is being displayed at medical schools and hospitals throughout the country. Until 27 May it will be on view at the Georgetown University Medical School in Washington, D.C.

Owned by the Philadelphia Museum of Art, the exhibition is being presented by Smith, Kline and French Laboratories. The scope of the show, which is thought to be the first collection of its kind, extends from medical illustrations designed for teaching purposes—such as those of Vesalius, Wechtlin, and others—to portrayals and critiques of medical procedures in the past.

A new table-of-contents service, ***Current Articles Unlimited,*** has been announced by the Spartan Co. This weekly publication will cover the contents listings of approximately 400 medical-science-technology journals. One copy of the entire coverage can be ordered for $75 annually, or a particular subject group can be subscribed to separately for $25. Multiple copies are offered at a great reduction in price and may be used for library circulation. For information write to the Spartan Co., 18 E. 17 St., New York 3, N.Y.

A copy of ***Amino Acid Biogenesis and Protein Synthesis,*** the proceedings of the symposium held recently at UCLA, may be obtained by sending $2 to M. S. Dunn, Chemistry Department, University of California, Los Angeles 24, Calif. Participants were Sidney Weinhouse, Bernard D. Davis, Philip P. Cohen, Alton Meister, Charles S. Hanes, and Halvor N. Christensen.

The **Federation of American Scientists** moved on 7 May from 1749 L St., NW, to new quarters at 1805 H St., NW, Washington 6, D.C.

Erratum: In the issue of 14 Jan., page 58, J. J. Thomson was incorrectly referred to as Lord Kelvin. As one of our readers has pointed out, J. J. Thomson was indeed eminent, but he was not Lord Kelvin.

Book Reviews

Antibodies and Embryos. F. W. Rogers Brambell, W. A. Hemmings, and M. Henderson. Athlone Press, London, 1951; John de Graff, New York, 1954. 103 pp. Illus. $2.25.

This small volume is based on the lectures given by Rogers Brambell before the University of London. It summarizes the work of the authors and their colleagues and collaborators in the Department of Zoology in Bangor, North Wales, on the passage of antibodies from mother to fetus in rabbits.

It is stressed that no attempt has been made to provide an exhaustive review of the literature on the transmission of passive immunity from mother to young in mammals. The authors also draw attention to the fact that their studies have been restricted to one mammalian species. Nevertheless, the straightforward and concise account of the problems studied, the logical consistency of the argument, and the technically elegant experiments on fetuses *in utero* that are described combine to make the volume one of considerable importance to all biologists. For the embryologist and comparative placentologist it has an interest far beyond the facts it records. Indeed, it has more than one moral, not the least of which lies in the origin of the work. That the whole investigation should have arisen out of observations on prenatal mortality in wild rabbits is a remarkable example of first seeing a problem and, then, of exploiting it. In its unpretentious presentation and simple format, this volume represents a distinctive contribution to knowledge.

J. D. Boyd

School of Anatomy,
University of Cambridge, England

The Physics of Viruses. Ernest C. Pollard. Academic Press, New York, 1953. xi + 230 pp. Illus. $5.50.

This little book is an attempt to collect and integrate the results of "biophysical" research on viruses. The main chapters are devoted to the size and shape of viruses as studied by means of electron microscopy, sedimentation, diffusion, and x-ray diffraction, and to the effects on viruses of ionizing radiations and ultraviolet light. A final chapter presents a brief review of bacteriophage multiplication, a number of imaginary virus structures, and some speculations on the nature of the physical forces involved in self-duplication.

Although the plan of this book seems well conceived, the discussions are generally unclear and the language rather careless. There are, furthermore, so many errors and omissions concerning both biological and physical matters that this compilation cannot be recommended as a good source of either facts or ideas about viruses to the general audience of biologists, chemists, and physicists to whom the author appears to be addressing himself. It should, however, be of some use to virus specialists, particularly as a handy summary of the work of Pollard and his associates.

Gunther S. Stent

Virus Laboratory,
University of California, Berkeley

Heat Conduction. With engineering, geological, and other applications. Leonard R. Ingersoll, Otto J. Zobel, and Alfred C. Ingersoll. Univ. of Wisconsin Press, Madison, rev. ed., 1954. xiii + 325 pp. Illus. $5.

Essentially a discourse on the partial differential equation for unsteady-state heat conduction or diffusion and its use in engineering calculations, this revised edition of a well-known textbook preserves the interesting flavor of the earlier editions and extends the mathematical methods to the currently active subjects of heat removal from the earth for use in a heat pump and of movement of moisture in consolidating soil. Although other books can lay claim to greater mathematical elegance and thoroughness, probably none are as effective as this one is in illustrating the use of heat-conduction computations for such a wide variety of purposes. This explanation, of what is often regarded by students as a difficult subject, is so well done that *Heat Conduction* should serve as a useful textbook in engineering courses at an advanced undergraduate level.

The authors make no apology for their selection of material, which emphasizes the application of mathematical computations rather than extensive treatment of methods for solving boundary-value problems. Throughout, they are consistent in their principal aim: to demonstrate that a few basic solutions of the heat-conduction equations can be employed for a variety of useful, frequently approximate estimates of physically interesting quantities.

Not many authors writing on this subject have such familiarity with geological problems, and these problems are among the most interesting in the book. For example, the earth's age is calculated from its rate of cooling; the time of occurrence of the latest glacial period is estimated from currently observed temperature distributions in the earth; the optimum arrangement of buried heat-transfer surface for removing heat from the ground is considered; and the rate of movement of a solid-liquid interface during freezing is treated—all applications of special interest.

Engineers should not expect to find anything approaching a complete treatment of the whole field of heat transfer in this book. Nor should they expect to find methods suitable for solving the majority of their practical problems, for no attention is paid to the transport of energy by convective motion of fluids or

by radiation. The authors are concerned solely with the conduction of heat in solids; in this one area, the reader is not likely to find another book so complete in its treatment of mathematical theory *plus* practical examples.

R. L. PIGFORD

Department of Chemical Engineering,
University of Delaware

Manufacture and Application of Lubricating Greases. C. J. Boner. Reinhold, New York 22, 1954. v + 977 pp. Illus. $18.50.

This book by C. J. Boner gives complete information on the subject and the fundamentals of the various lubricating greases. With its presentation of theories and concepts of structure, as well as of the more practical phases, it should be valuable for research, for technical lubricating problems arising in industry, and for the use of equipment designers. Since no one lubricating grease is best for all applications, this book will guide maintenance men in selecting the right grease for each specific use and in determining how best to apply it in order to reduce wear and tear on machinery and down-time.

There are some lubricating applications for which greases are superior and others for which the use of oils is not even feasible. There is no truly all-purpose lubricating grease, but there are, however, multipurpose greases. The type of grease best suited for heavy shock loads is not necessarily best for other purposes that may be required of it. The same can be said for use at high temperature, against corrosive chemicals or abrasive dusts, and other uses. Application requirement and care can differ from one type of lubricating grease to another, coupled with the fact that a component of some types of grease may be deleterious if it enters the product being made.

This should make an excellent textbook for advanced study and for those in the technical phase of lubricating grease manufacture. The numerous illustrations, micrographs, plates, graphs, and tables greatly contribute to the understanding of the subject matter. There is a complete bibliography for each phase, and the subdivisions of each chapter, as well as each illustration, are numbered and titled for easy reference.

The complete raw materials section is not only an aid to improvements for the lubricating grease manufacturers but it is also an aid for the suppliers of these raw materials. I have already put to practical use, both privately and professionally, this interesting and instructive book on lubricating greases.

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Technical Papers

Effects of Temperature, Light, and Nutrition on the Sensitivity of the Male *Rana pipiens* to Exogenous Chorionic Gonadotropin

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A variable decrease in the sensitivity of male *Rana pipiens* to exogenous chorionic gonadotropin during the summer months has limited their use in the bioassay of this hormone (*1–6*). The decrease in sensitivity has been variously attributed to temperature (*2–4*), breeding period (*3–5*), and illumination (*6*). Cutler (*7*), experimenting during the summer with male *R. pipiens* that were kept in a refrigerator, observed no seasonal breeding period variation.

This paper reports the results of a series of experiments designed to evaluate the effects of temperature, light, and nutrition on the sensitivity of the male *R. pipiens* to exogenous chorionic gonadotropin (*8*) and thereby to establish the optimum environment for the use of this amphibian in the bioassay of this hormone.

After receipt, the frogs were stored for 1 wk in an outdoor cage with running tap water and an environmental temperature ranging from 15° to 19°C. All frogs were then screened with 20 and 40 IU of chorionic gonadotropin. Those that reacted positively were given an additional 1-wk resting period in the same environment (*9*). The screening process was designed to eliminate refractory male frogs or females not detected previously by their sexual characteristics (*2, 10*). Only male frogs that reacted positively to 40 IU of chorionic gonadotropin and with body weights ranging from 35 to 40 g were selected for this investigation. Of the 760 frogs received from October 1953 through May 1954, 623 (82 percent) reacted positively to 40 IU of chorionic gonadotropin. The fact that 137 frogs (18 percent) of those screened reacted negatively emphasized the importance of screening all animals before using them experimentally. On two occasions during the 2-wk period of screening, all frogs were force-fed 1 to 2 g of whole

Table 1. Summary of results of all experiments. Light was supplied from a 100-w bulb. Day of injection was computed from the first day on which environment was imposed.

Group	Environmental conditions			Hormone injected (IU)	Day of injection	No. of frogs injected	No. of frogs positive	Percentage positive
	Temp. (°C)	Light	Nutrition					
1	28	Illuminated	Fed	20	13	39	7	18
				30	32	38	12	53
				40	45	37	29	78
2	21	Illuminated	Fed	20	13	38	14	37
				20	49	34	12	35
				30	33	34	22	65
				40	44	34	31	91
3	6	Illuminated	Fed	20	13	36	19	53
				30	33	34	34	100
				10	49	31	8	26
4	28	Total darkness	Fed	20	20	36	6	17
				30	38	36	4	11
				30	65	36	2	6
				40	74	30	0	0
5	5	Total darkness	Fed	10	14	28	7	25
				20	29	27	9	33
				30	36	15	4	27
6	20	Illuminated	Starved	20	60	20	3	15
				30	75	20	6	30
				40	92	20	9	45
7*	28	Illuminated	Fed	30	17	29	0	0
				30	49	26	0	0
				40	31	27	0	0
				40	65	26	0	0

* This group consisted of the same frogs as group 4.

liver. "Red-leg" infection was prevented by the use of sulfathiazole.

Eight to 10 frogs were placed in 8- by 8-in. glass jars that contained about ½ in. of tap water, which was changed weekly or as required. The temperature was recorded daily. At the time intervals indicated in Table 1 the frogs were injected in the dorsal lymph sac with 1 ml of an aqueous solution of chorionic gonadotropin containing 10, 20, 30, or 40 IU. Before each injection the urine of the frogs was checked to insure that it was sperm-free. Each frog's urine was checked for the presence of sperm at 1, 1½, and 3 hr after the injection.

The positive frogs in groups 1, 2, 4, 6, and 7 were returned to their respective experimental environments after the results of their injection were established; the positive frogs in groups 3 and 5 were kept at room temperature, with and without illumination, respectively, for approximately 5 days to insure elimination of all liberated spermatozoa (*9, 11*). The negative frogs of groups 3 and 5 were kept at room temperature for about 6 hr before they were returned to the refrigerator.

The frogs in groups 1, 4, and 7 were kept in an incubator and those in groups 2 and 6 were kept in an unheated, unventilated room.

Illumination was supplied from a common, unfiltered, 100-w light bulb. Feeding was accomplished by forcing a small piece of beef liver (1 to 2 g) down the animal's esophagus.

Table 1 summarizes the results of all the experiments performed. The concentration is expressed in International Units (1 IU = 0.1 mg). The day of injection was computed from the first day on which the experimental environment was imposed. The frogs in group 7 were the same as those in group 4. After these animals had been maintained in total darkness for 74 days, they appeared to be permanently sterile, for they failed to respond positively to 40 IU of chorionic gonadotropin after 65 days of exposure to constant illumination (group 7).

Figure 1 presents the dose-response curves for groups 1, 2, 3, 4, and 5. The percentage responding positively is plotted against the concentration of chorionic gonadotropin injected. It is evident from this figure that light has a more pronounced effect on the sensitivity than temperature.

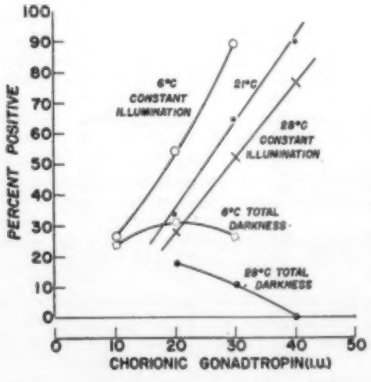

Fig. 1. Dose-response curves for groups 1, 2, 3, 4, and 5.

Comparison of groups 2 and 6 in Table 1 reveals that nutrition also affects the sensitivity. However, work in progress here indicates that nutritional effects are negligible when the animal is maintained at refrigerator temperature.

The following recommendations are made on the basis of these findings: (i) For maximum sensitivity to exogenous chorionic gonadotropin, male *R. pipiens* should be maintained at refrigerator temperature, under constant illumination, and in a state of good nutrition. (ii) All frogs should be screened, after having been thus maintained for a 2-wk period, to establish their sensitivity to the hormone and to eliminate females and refractory males. (iii) Under these conditions we have observed that 50 and 100 percent respond to 20 and 40 IU of chorionic gonadotropin, respectively.

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Unique Electron Exchange Polymer

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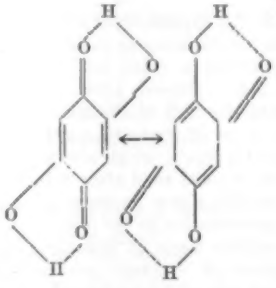
The field of electron exchange resins was initiated by Cassidy when he showed that polyvinylhydroquinone had reversible redox properties (*1*). His first product was readily soluble in many common organic solvents, indicating a low degree of polymerization. However, on copolymerization of vinylhydroquinone and divinylbenzene, he obtained a cross-linked, insoluble, infusible redox resin, which was shown to be useful for electron exchange experiments in columns (*2*).

Manecke measured the oxidation potentials of the redox polymers resulting from the condensation of

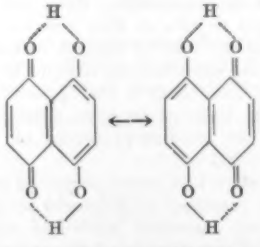
the polyphenols hydroquinone, catechol, and pyrogallol with formaldehyde (*3*). The values obtained for the polymers were close to those of related polymethylated polyphenols. For example, the E_0 of the polymer prepared by condensing hydroquinone, phenol, and formaldehyde in the ratio of 1:1:2 was 0.70 v. The corresponding value for tetramethylhydroquinone was 0.69 v. Similarly, the values obtained by Cassidy and his coworkers for ethylhydroquinone, vinylhydroquinone, and polyvinylhydroquinone (later shown to be mostly dimer and trimer) were 0.64, 0.67, and 0.68, respectively.

In considering other polyphenols that could be condensed with aldehydes to form redox polymers, certain tetrahydroxy derivatives seemed attractive because of greater potential and capacity (*4*). These are the isomers in which the four hydroxy groups are present as adjacent pairs on a benzene ring or are juxtaposed on a polyaromatic ring system so that a hydrogen-bonded dihydroxyquinone results as the first oxidation step. Some examples are 1,2,4,5-tetrahydroxybenzene, 1,2,3,4-tetrahydroxybenzene, 1,4,5,8-tetrahydroxynaphthalene, and 3,4,3′,4′-tetrahydroxy biphenyl.

The resonance symmetry of the intermediate hydrogen-bonded dihydroxyhydroquinone stage, as is shown in the structural formulas for two of the examples cited, should increase the stability of this oxidation state in relation to the tetrahydroxy and diquinone states. Hence, when such a material is in



2,5 Dihydroxy 1,4 benzoquinone



5,8 Dihydroxy 1,4 naphthoquinone (naphthazarin)

either of the extreme reversible oxidation states, it should have better oxidation and reduction potentials than some other polyphenol-quinone couple that does not possess such a stabilized intermediate state. This idea can obviously be extended to more complex systems having more than four hydroxy groups.

The values for the oxidation potentials of the couples 1,4,5,8-tetrahydroxynaphthalene-naphthazarin and naphthazarin-naphthodiquinone are 0.37 and 0.93 v, respectively (*5*). One might expect slightly lower values for a polymer of this material and formaldehyde because alkylation usually decreases the oxidation potential. Disregarding this and other minor effects, it was deemed possible to prepare a resin that could oxidize or reduce any couple whose oxidation potential lies between these values.

In order to test this hypothesis, a naphthazarin-formaldehyde polymer was prepared (*4*). Five grams of naphthazarin was dissolved in a mixture of 500 ml of glacial acetic acid and 50 ml of concentrated sulfuric acid. Excess zinc dust was added and the mixture was refluxed until the color of the solution changed from red to a pale grayish green. Excess trioxane was then added and the refluxing was continued for 5 hr. The resulting black precipitate was filtered, and then boiled with several portions of glacial acetic acid, 1 normal aqueous hydrochloric acid, and water in order to remove any low-molecular-weight polymers, other organic reaction products, zinc dust, and zinc salts. The polymer, when dried in a vacuum, was brown.

An attempt was made to determine the oxidation potentials of the oxidation states of this polymer by potentiometric titration with ceric sulfate. However, our experience was similar to Cassidy's and Manecke's. A slow downward drift of potential resulted after each addition of oxidant solution. We found that at least 10 hr were needed to half-titrate a given sample, and even then we were never sure that the potentiometric readings were equilibrium values. Cassidy concluded that the titration of his copolymers should be considered as "semiquantitative" for similar reasons. Qualitative experiments, however, proved that either member of the couples I^-, I_2; $Fe(CN)_6^{4-}$, $Fe(CN)_6^{3-}$; and Fe^{2+}, Fe^{3+} could be oxidized or reduced, depending on the state of the resin. The standard electrode potentials of these couples are -0.54, -0.69, and -0.77 v, respectively.

The qualitative tests demonstrating the oxidation properties of the resin were run as follows. Approximately 1 g of resin was treated with excess acidified ceric ammonium sulfate solution. After thorough mixing for a few minutes, the excess oxidant solution was removed by centrifugation. The polymer was then washed with successive portions of distilled water until ceric ion was absent from the final washing. The washed polymer was then treated with a ferrous sulfate solution. One could see the immediate formation of a yellow color. The solution was centrifuged, and the centrifugate was treated with thiocyanate. The deep red color showed the presence of ferric ion. The resin was then washed by centrifugation with excess water until apparently free from

ferric ion. However, it was found that this treatment was insufficient for the removal of all the ferric ion from the resin. It seems that in the naphthazarin state the resin functions as an ion exchanger. It was necessary to treat the resin with 3 normal hydrochloric acid to effect complete removal of ferric ion. This cycle was repeated five times in all for the oxidation of ferrous ion. In the same manner, the oxidation of iodide ion and ferrocyanide ion was proved.

The reducing properties of the resin were shown in a similar way. Approximately 1 g of resin was treated with excess sodium hydrosulfite and was then washed free of excess reductant. A solution of ferric chloride was added to the reduced polymer. The centrifugate showed the absence of ferric ion by test with thiocyanate. Addition of hydrogen peroxide to this test mixture gave a deep red color, showing the presence of ferrous ion. The polymer was regenerated by treatment with 3 normal hydrochloric acid and successive water washes. This cycle was also repeated five times in all. The reduction of ferricyanide and iodide ions was similarly demonstrated.

In view of the fact that ferric ion was picked up by the resin when it was presumably in the naphthazarin oxidation state, several other ions were tested for exchangeability. It was found that Ni^{2+}, Cu^{2+}, and Co^{2+} were readily picked up and eluted.

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27 January 1955.

Alterations in Serum Properdin Levels Following Injection of Zymosan

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The discovery and isolation of properdin, a new serum protein that participates in many immune reactions, has been described recently (*1*). Properdin acts in conjunction with complement or complement-like substances and requires Mg^{++} for its activity (*1*). Available evidence suggests that this system plays an important role in natural immunity.

Zymosan (*2*), the insoluble cell-wall residue from yeast, combines with properdin *in vitro*. This provided the basis for the isolation of properdin (*1*). Experiments directed toward a better understanding of the role of the properdin system in experimental infections and other disease states have now shown that the injection of zymosan causes marked alterations in the serum properdin levels of laboratory animals (*3*).

A series of experiments has been conducted in which healthy 12- to 16-g CF1 female mice, and 175 to 200-g Wistar rats were injected intravenously or intraperitoneally with various doses of a boiled saline suspension of zymosan (*4*). Changes in the properdin content of the blood were followed by doing titrations (*1*) on pools of at least six serums obtained from groups of animals sacrificed at various times before and after injection. The serum samples were frozen and stored at −70°C in a mechanical deep freeze until the last sample had been obtained. Properdin titrations were then done on all the samples with the same reagents on the same day. Some of the samples were also titrated for complement and for C'3.

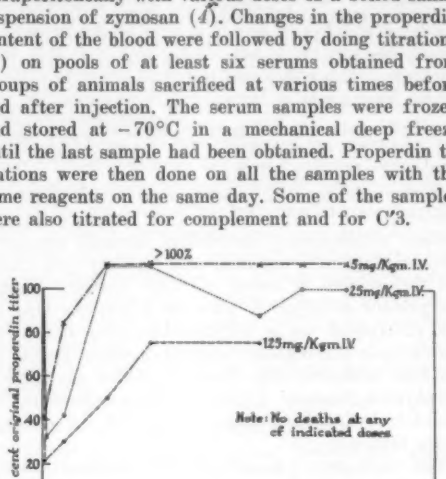

Fig. 1. The serum properdin levels in mice following intravenous injection of zymosan.

The results of a typical experiment with mice (Fig. 1) show that the intravenous injection of small doses of zymosan caused a rapid fall in properdin titer within 1 to 2 hr, followed, after 2 to 14 days, by a marked rise in titer 200 to 300 percent above normal level. Large doses of zymosan caused a greater fall in the properdin levels, which slowly returned to 75 percent of the normal level after 6 to 10 days. It is, therefore, possible either to decrease or increase the properdin concentration in the serums of mice by injection of suitable doses of zymosan. The intraperitoneal injection of zymosan produced similar, although slower and more prolonged, changes in the properdin titers. A more detailed report of these experiments is in preparation. Rats and rabbits behaved similarly to mice in their reaction to zymosan. In contrast to the marked changes in properdin following zymosan injection, no changes were observed in C'3 titers. This result is the opposite of that expected on the basis of *in vitro* experiments which showed that the zymosan-properdin complex inactivates C'3 at 37°C (*1*).

The observation that serum properdin levels in animals may be increased or decreased by injection of zymosan under controlled conditions now offers a means for studying the role of the properdin system in experimental infections and other disease states. Indeed, Derrick Rowley, at the Wright-Fleming Institute of Microbiology, London (personal communication), recently found that the injection of zymosan

into mice caused marked changes in their susceptibility to experimental *Escherichia coli* infection. During the first hour after zymosan injection, the mice became highly susceptible to infection with an *E. coli* strain that was avirulent for normal mice. Moreover, during the period between 2 and 5 days after injection of zymosan, the mice were highly resistant to a different *E. coli* strain that was fully virulent for normal mice. In addition, Rowley found that rats which are naturally resistant to *E. coli* infection were killed by this organism if zymosan had been injected with 1 hr preceding challenge.

These experiments suggest that the initial fall and secondary rise in blood properdin that we have found to follow zymosan administration may influence the increase and decrease in natural resistance of the animals in Rowley's experiments. Experiments to be published in detail elsewhere (*5*) also show that the injection of zymosan into mice or rats can markedly increase or decrease their susceptibility to the effects of lethal doses of total-body irradiation depending on the dose and the time of injection.

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Observations on Growth Responses to Antibiotics and Arsonic Acids in Poultry Feeds

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During the past few years the relative growth responses that we have obtained when low levels of antibiotics and arsonic acids were added to poultry feeds have been progressively decreasing. Recent tests have sometimes shown a total lack of response.

Several different antibiotics, arsonic acids, basal rations, and breeds of chickens have been used in our experiments (*1*). However, equipment, management, and sanitation practices were reasonably uniform from year to year. The facilities for growing chickens have been in use almost continuously for many years, so that the environment may be considered "old" rather than "new."

Birds were started at 1 day of age and were carried for 3 to 6 wk on wire floors in batteries or up to 10 wk on corncob litter in a brooder house with heated floors. Feeds and water were offered *ad libitum*, and lights were used for 24 hr a day in the battery room and 14 hr a day in the brooder house.

Table 1 gives the yearly percentage growth response of birds fed rations containing antibiotics or arsonic acids over those fed control rations without these additives. Although the data for arsonic acids are not as extensive as those for antibiotics, both substances showed a similar trend—a progressive percentage decrease in response. Inasmuch as these chemicals exert their influence on nutrition in the same manner (*2*), their data are combined in column 3. This table contains data on 3900 chicks in 146 comparisons between groups of birds that were simultaneously fed the control rations or these same rations containing dietary levels of antibiotics or arsenicals.

It is seen that during the first year these substances considerably improved the early growth of chicks. This occurred on all basal diets. The response to antibiotics and arsonic acids, however, has since been progressively decreasing. Waibel (*3*) recently noted this in the case of dietary penicillin and Aureomycin during a 3-yr period.

At first sight this decreasing response appeared to be in accord with the idea that antibiotics may lose their effectiveness with continued usage, because of the gradual establishment of a microflora resistant to the antibiotics (*4*). If this were the case, the value of such additives would decrease in the course of time with prolonged use in the same place.

However, before this inference is drawn from the data presented, the growth rate of birds that were not fed antibiotics or arsonic acids should be noted. As is

Table 1. Growth responses from dietary antibiotics and arsonic acids and the mortality by years. The figures in parentheses indicate number of comparisons with control birds.

Periods	Increase in weight with respect to birds fed the control ration (%)			Increase in weight of control birds with respect to 1950–51 control birds (%)	Mortality to 6 wk of age (%)
	Birds fed antibiotics	Birds fed arsonic acids	Average		
1950–51	19.0 (75)	16.0 (2)	18.9	0	8.5
1951–52	12.8 (32)	(0)	12.8	7.4	8.2
1952–53	10.0 (4)	3.8 (5)	6.5	15.3	4.6
1953–54	3.3 (19)	3.2 (9)	3.2	19.1	2.8

evident in column 4, the weights of the control birds have been gradually increasing. For example, in 1950–51 certain groups of White Leghorn cockerels weighed 330 g at 5 wk of age, whereas in 1953–54 the same breed and strain of birds, on the same ration and in the same batteries, weighed more than 400 g. During the same period, the 4-wk weights of New Hampshire chicks that had antibiotics in their ration increased from 385 g to 406 g. Thus, both control and antibiotic-fed birds increased in weight during the last 4 yr, but the former gained at a much greater rate than the latter. The apparent decreased effectiveness of the growth promotants, therefore, is caused by a relatively greater increase in the rate of growth of birds fed the control ration.

These data, thus, do not furnish support for the theory that the continued use of antimicrobial agents in feeds results in the proliferation of resistant strains of organisms that eventually cause these agents to become ineffective. Rather, the data can be interpreted from an entirely different viewpoint—that is, that their continuous use over a long period produces an environment with a lowered germ load or disease potential. After long-time usage, these growth promotants are still capable of suppressing the germ load, but less of a challenge is presented. Thus, birds that are grown on the premises where birds have or have had antibiotics or arsonic acids in their feeds benefit to some extent from the improvement in environment.

The reduction in the mortality of chicks that we have observed during the last 4 yr adds support to the postulation that a reduced germ load develops. As can be seen in column 5, prior to the inclusion of antibiotics and arsenicals in chick rations, the mortality of battery-raised chicks up to 6 wk of age was about 8.5 percent, whereas the mortality of birds in these same batteries in recent years has declined to less than 3 percent. In addition, fewer cull chicks and less variability in growth rate within pens are now being noted.

From the practical point of view, this study indicates that antibiotics and arsonic acids would be of greatest value in promoting growth (i) when first used in a poultry-feeding enterprise and (ii) under the environmental conditions usually surrounding farm feeding. If once used and then discontinued, feeding performance may still be somewhat improved, because the contamination level has been lowered. Continued use of these substances at low levels, however, would help to insure maximum results, because an "infected" area can be reestablished through disuse (*5*). Indications are that such use of antibiotics and arsonic acids in feeds will not build up a resistant microflora that future poultry populations will have difficulty to live with.

From the point of view of the laboratory that attempts to evaluate antibiotics and arsonic acids for growth promotion, it would be desirable to be able to create at will a controlled level of contamination so that these substances can be tested under conditions more comparable to those in the field. Investigations along these lines are under way.

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24 January 1955

Straight-Line Function of Growth of Microorganisms at Toxic Levels of Carbon Dioxide

Richard D. Durbin

Department of Plant Pathology, University of California, Los Angeles

Although CO_2 is essential for the growth of many heterotropic organisms (*1*), at high concentrations it becomes toxic (*2–4*). Such toxic action may, in part, be upon the CO_2-fixation mechanism itself (*5*).

Studies have been conducted to determine the influence of various concentrations of CO_2 upon the growth of several fungi (*2–4*). It has been found that these data will fit a straight-line dosage-response curve when they are plotted on a log-log scale, examples of which are shown in Fig. 1. Bateman's (*6*) method was employed by plotting the logarithm of the CO_2 concentration versus the logarithm of the

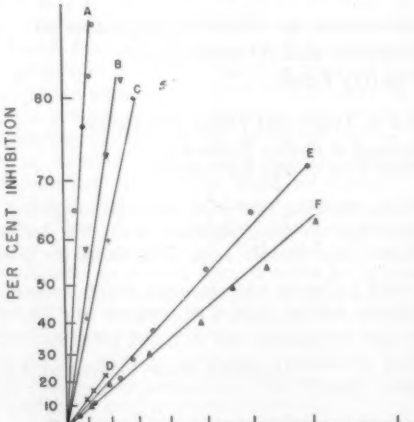

Fig. 1. Inhibition of growth at various levels of CO_2 for (*A*) *Penicillium nigricans*, (*B*) *Alternaria grossulariae*, (*C*) *Cladosporium herbarum*, (*D*) *Ophiobolus graminis*, (*E*) *Fusarium oxysporum*, and (*F*) *Fusarium solani f. cumartii*.

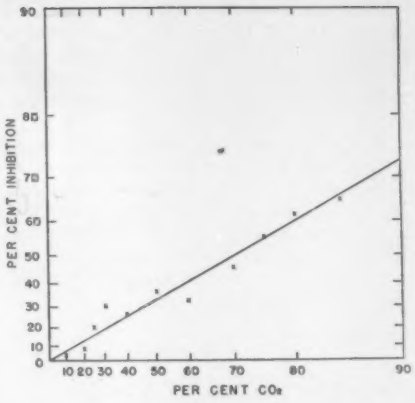

Fig. 2. Inhibition of growth at various levels of CO_2 for *E. coli*.

percentage inhibition of growth at that concentration. The slope of the CO_2-response curve depends on the temperature and the organism's response to CO_2. As the temperature departs from the optimum for growth, the response slope becomes steeper as a result of increased growth inhibition at lower temperatures for any given CO_2 level (*2, 4*). The effect of temperatures higher than the optimum has not been studied.

Experimental studies were carried out at 25°C to determine the amount of growth of *Escherichia coli* under different CO_2 concentrations. Test tubes containing equal amounts of bacteria in nutrient broth were placed in sealed 1-lit flasks containing the desired atmospheric mixture and placed on a shake machine for 24 hr. The oxygen concentration was maintained at 20 percent, except at the 85- and 90-percent CO_2 levels, where the oxygen concentration was 15 and 10 percent, respectively. Growth was expressed as a function of the amount of turbidity produced in the test tubes. The results plotted on a log-log scale are presented in Fig. 2.

The fit of the data, both experimental and from the literature, would seem to justify the validity of this method. The use of this type of representation has several advantages: (i) it makes possible direct comparisons between organisms; (ii) errors in collected data become immediately apparent; (iii) a large number of data may be presented graphically without confusion; and (iv) it makes possible the experimental determination of only a few growth points, with the others derived from the graphic representation. An inherent drawback, however, is that data derived from two organisms grown at the same temperature may not be strictly comparable if the optimum growth temperatures lie far apart.

It can be seen from Fig. 1 that the curves of organisms (*D, E,* and *F*) that are capable of growth in the lower soil depths are more gently sloping than surface or aerial types (*A, B,* and *C*). This means that at any particular CO_2 concentration, their growth is inhibited less than the growth of organisms that are usually confined to upper soil leaves or aerial environments. This tolerance to CO_2 probably plays an important part in their occurrence in a subterranean environment where concentrations of CO_2 normally range from 3 to 10 percent. Their ability to grow at lower soil levels allows them to escape competition with the many microorganisms that exist at or near the soil surface.

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31 January 1955.

Communications

Carbon-14 Dates from Ellsworth Falls, Maine

Through the kindness of H. R. Crane and the Radiocarbon Laboratory, Michigan Memorial-Phoenix Project, the ages of two samples submitted by us have been obtained. These samples were taken from the Smith Farm, Ellsworth Falls, Maine, during a program of excavation covering the summers of 1947–50, inclusive, under the auspices of the Robert Abbe Museum of Bar Harbor, Maine, and the Robert S. Peabody Foundation for Archaeology. They yielded the first radiocarbon dates for the archaic in eastern New England.

Sample M-89 was taken from a pit that appears to equate with middle levels of the deposit including archaic remains of Red Paint character. Above it was a deposit comprising floors in which sherds of Vinette I pottery and later Point Peninsula pottery types were found. Although two pits containing Vinette I sherds were at comparable levels, they could be traced upward to these floors and are not connected in any way with sample M-89. Two runs of this sample produced the following: first run, 4150 ± 450 yr; second run, 3800 ± 400 yr. The average age is therefore 3959 ± 310 yr, or 2005 B.C.

Sample M-90 was taken from a pit that appears to equate with the latest expressions of archaic Red Paint. It assayed at 3350 ± 400 yr, or 1400 B.C.

A more complete description of conditions and associated artifacts will appear in the January 1956, issue of *American Antiquity*.

DOUGLAS S. BYERS
Robert S. Peabody Foundation for Archaeology, Phillips Academy, Andover, Massachusetts

WENDELL S. HADLOCK
Farnsworth Library and Art Museum, Rockland, Maine

15 February 1955.

To Users of the Hunter Color and Color Difference Meter

Since there has been a considerable amount of interest in our paper "New method of presentation of food samples to the Hunter color and color difference meter" [*Science* **120**, 666 (22 Oct. 1954)], we have prepared detailed blueprints of the spinning attachment described in the article. Those who wish to build the instrument for use in their own laboratories may obtain copies of these drawings from the Department of Food Technology, Oregon State College.

A. P. SIDWELL
Department of Food Technology, Oregon State College, Corvallis

21 March 1955.

On Hazards of Nuclear Power Plants

Weil's article, [*Science* **121**, 315 (1955)] was very interesting, although some details of the case of the Chalk River misfortune would have brought the discussion more into the realm of the here-and-now than the apparently purely theoretical.

I would like to suggest a type of design for power reactors that would confine disaster by-products to the premises and, perhaps, save the major portion of the plant from contamination.

If a reactor were built of massive construction as to tensile strength and mass of the walls and top, if the floor of the containing building were of similar construction, and if the whole were hermetically sealed, with the floor of the reactor relatively weak, blow-out and gravity would express the contents downward. Underneath, a large water trap would receive the debris and gas, the walls of the building extending well down into the reservoir, with a moat of sufficient dimensions around the building to accommodate the water displaced from the reservoir. A sufficient air-filled space above the water in the reservoir would act as a pneumatic cushion during the initial surge in order to permit the water mass to be displaced without undue shock.

Dimensions should be such that all gases would be confined to the inner chamber; excess volume and pressure would only reduce the reservoir chamber level to the point where it would pass under the intervening wall and up through the deep water in the moat. Condensation by cooling and by going into solution under the conditions of turbulence and pressure would greatly eliminate the initial volume of gas produced.

Confining the radioactive materials to the underground chamber, with only flat surfaces to be decontaminated, would greatly facilitate reconditioning; and the floor and tunnel across the moat of heavy construction would insure maximum protection to personnel and would permit early reactivation.

CHARLES C. LITTELL, JR.
434 Patterson Road, Dayton, Ohio

11 March 1955.

Graphic Determination of Averages

In describing the graphic procedure for determining a simple arithmetic average, S. I. Askovitz [*Science* **121**, 212 (1955)] reports his inability to discover an applicable precedent in the relevant literature. This deficiency probably results from greater interest in graphic moving averages, which statisticians occasionally employ. To my knowledge, McChesney (*1*) has been the only investigator to deal with the subject formally. A brief elaboration should in no way detract from Askovitz' sound logic.

Suppose the points at the coordinates (x_1,y_1), (x_2,y_2), (x_3,y_3), and (x_4,y_4) are A, B, C, and D, respectively. Let b be the point at one-half the distance from A to B; and, similarly, let c be the point at one-half the distance from B to C. Connect b and C with a ruler, and at $x=2$ designate m_1 (*2*). Next connect c and D, and at $x=3$ designate m_2. The readings for m_1 and m_2 express the two three-point moving-average values for the four y's. This technique can be adapted to other types of moving averages, including those reiterated.

After plotting a series of (equally weighted) observations on a scatter diagram, an analyst usually wants prompt answers to two questions before proceeding to more detailed objective treatment: (i) Are the data normally distributed? (ii) What would a smoothing disclose concerning the trend, or curve, of mean relationship? The analyst would answer the first question by passing perpendiculars through the two medians and seeing how the observations are arranged. In the absence of any compulsion to start over again with the y-values, x-values, or both transformed into more tractable form, an appropriate moving average may afford the basis for drawing a freehand curve, or provide a clue to the function that will best depict the central tendency.

GEORGE W. HERVEY
American Red Cross, Washington, D.C.

References and Notes

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2. I located m_1 in the process of arriving at a simple average.

24 February 1955.

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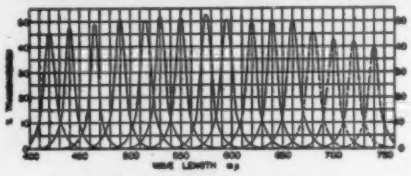

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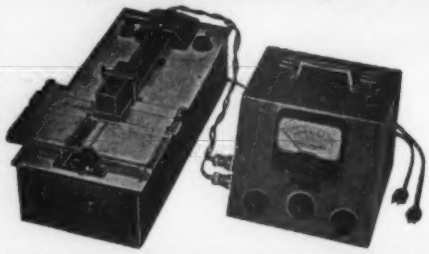

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Sex in Microorganisms

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The genetic, physiological, and morphological evidence for "sex" in the principal groups of microorganisms—viruses, bacteria, fungi, unicellular algae, and protozoa—is presented by a group of experts in the field.

N. Visconti of the Carnegie Institution of Washington at Cold Spring Harbor, discusses recombination of "genes" in viruses. J. Lederberg of Wisconsin and E. L. Tatum of Stanford review genetic evidence for "sex" in bacteria, and W. G. Hutchinson of Pennsylvania and H. Stempen of Jefferson Medical College describe cell fusions in certain bacteria. J. R. Raper offers a comprehensive coverage of sex in fungi.

R. Patrick of the Academy of Natural Sciences, Philadelphia, describes syngamy in diatoms; R. A. Lewin of the Maritime Regional Laboratory, Halifax, the sexuality of other unicellular algae, especially the flagellates.

In two chapters D. H. Wenrich covers sexual phenomena in some of the protozoa and discusses the origin and evolution of sex, based primarily on the protozoa, but including material about all of the microorganisms. D. L. Nanney of Michigan summarizes mating-type phenomena in *Paramecium aurelia* and some of the recent mating-type work from Sonneborn's laboratory. C. B. Metz of Florida State compares mating-type substances in *Paramecium* and other ciliates with those found in Metazoa. Extensive chapter bibliographies are included.

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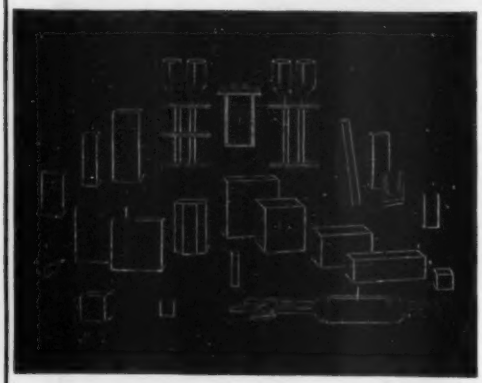

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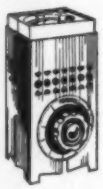

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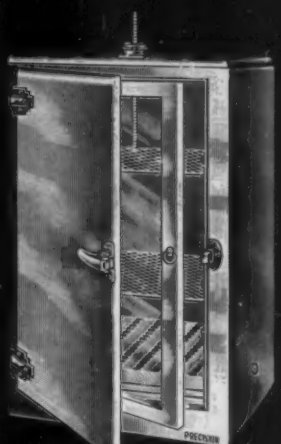

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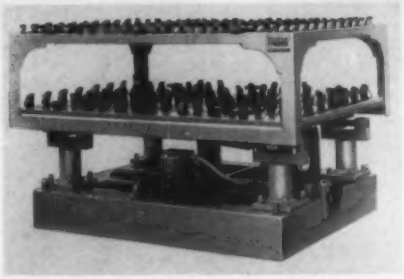

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Salaries of Officer-Scientists

CURRENT regulations of the military services and the U.S. Public Health Service provide physicians, dentists, and veterinarians on active duty as commissioned officers with salaries $100 a month higher than those of nonmedical officers of equal grade. Without begrudging their medical colleagues the benefits an extra $100 a month can bring, the differential pay scale simply does not look fair to the chemists, biologists, psychologists, and other scientists who have Ph.D. degrees and who are on duty as commissioned officers.

The differential has sometimes been defended as compensation for the long time required to earn a degree in medicine. But the ground was cut from under this argument—if it ever had validity—when the pay differential that physicians and dentists had earlier enjoyed was extended to veterinarians. If the higher pay is intended to compensate men for an additional 3 or 4 years of professional training, it should go to officers with doctor's degrees in other fields as well as to holders of doctor's degrees in medicine, dentistry, and veterinary medicine.

Perhaps the differential should be abolished. Representative Teague has thought so and has introduced into the Congress a bill (H.R. 2442) which would, if passed, provide a salary bonus of $100 a month for each officer "who holds a doctor's degree (or its equivalent) in mathematics, physics, chemistry, or in a comparable science . . . and who is performing duties in the field in which he holds such degree." The officer-scientists who would benefit are, of course, hoping that the bill will be passed and, insofar as their positions permit, are supporting it. Passage is doubtful, for the bill has no popular appeal and little general support. It even has some strong, although not always announced, opposition from the medical branches of the services, for some medical officers fear that public or Congressional attention to the differential may result in abolishing their own bonus instead of providing one for their scientific colleagues. This fear is not wholly selfish; if the bonus for medical officers should be abolished, the number of resignations might make it even more difficult to maintain satisfactory military medical service.

The pay differential is part of a larger problem of the scientists who hold military or U.S. Public Health Service commissions for duty in conjunction with the medical services. For example, the Medical Service Corps of the Army—the corps that includes scientist-officers who work with members of the Medical Corps—is the only Army corps in which there is no possibility under current regulations for any officer to attain the rank of general. Even the very small Veterinary Corps is headed by a general, but the many times larger Medical Service Corps is headed by a colonel.

Some of these inequalities may in time be erased. In fact one has. Until about a year ago the Army's Medical Service Corps was authorized to have only 2 percent of its officers at the grade of colonel, whereas all other Army corps were authorized 8 percent. A year ago the officer strength of the Medical Service Corps was readjusted to permit 8 percent to hold the rank of colonel.

Depending upon their temperaments, officer-scientists have been more or less rankled by these inequalities. They have, of course, chosen their careers despite the conditions. But this does not mean that they should not seek better conditions. Now that Representative Teague's bill is before the Congress, they see a possibility of a little better monetary reward for their work. They have good arguments on their side, but custom prevents them from speaking out in an effort to influence legislation. They must sympathize with Veblen, who is reputed to have replied to a question concerning the outcome of a doubtful event with the comment: "I hope and pray that it will succeed, but I pray more than I hope."—D.W.

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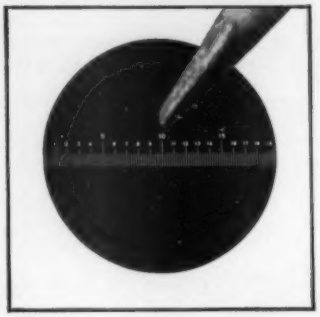

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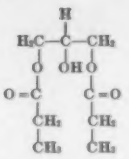

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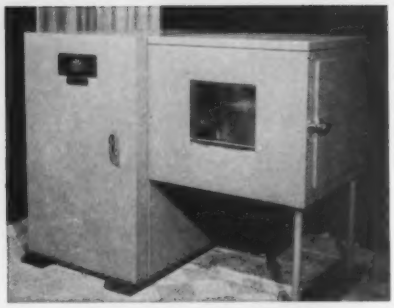

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Meetings & Conferences

June

20–23. American Soc. of Mechanical Engineers, semiannual meeting, Boston, Mass. (O. B. Schier, 29 W. 39 St., New York 18, N.Y.)

20–23. Inst. of Aeronautical Sciences, Los Angeles, Calif. (S. P. Johnston, IAS, 2 E. 64 St., New York 21.)

20–23. International Powder Metallurgical Cong., Reutte, Tyrol, Austria. (P. Schwarzkopf, American Electro Metal Corp., 551 Fifth Ave., New York 17.)

20–24. American Assoc. of Physics Teachers, joint meeting with American Soc. for Engineering Education, State College, Pa. (M. W. White, Pennsylvania State Univ., State College.)

20–24. American Physical Therapy Assoc., St. Louis, Mo. (M. Elson, 1790 Broadway, New York 19.)

20–24. British Medical Assoc. annual, Toronto, Ontario. (A. D. Kelly, Canadian Medical Assoc., 244 St. George St., Toronto 5.)

20–25. AAAS, Pacific Div., Pasadena, Calif. (A. W. Galston, Biology Div., California Inst. of Technology, Pasadena 4.)

20–25. Symposium on Electromagnetic Wave Theory, Ann Arbor, Mich. (J. W. Crispin, Jr., Univ. of Michigan, Ypsilanti.)

20–25. Western Soc. of Naturalists, Pasadena, Calif. (D. Davenport, Santa Barbara College, Santa Barbara, Calif.)

21–22. Astronomical Soc. of the Pacific, Pasadena, Calif. (S. Einarsson, Leuschner Observatory, Univ. of California, Berkeley 4.)

21–23. American Dairy Science Assoc., East Lansing, Mich. (E. Weaver, Dairy Dept., Michigan State College, East Lansing.)

21–23. American Meteorological Soc., Pasadena, Calif. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

22–24. American Physical Soc., Toronto, Canada. (K. K. Darrow, APS, Columbia Univ., New York 27, N.Y.)

26–1. American Soc. for Testing Materials, annual, Atlantic City, N.J. (R. J. Painter, 1916 Race St., Philadelphia 3, Pa.)

26–1. National Education Assoc., Chicago, Ill. (W. G. Carr, 1201 16 St., NW, Washington 6, D.C.)

27–29. American Nuclear Society, 1st annual, University Park, Pa. (W. W. Miller, Pennsylvania State Univ., University Park.)

27–29. American Soc. for Engineering Education, Thermodynamics Conf., University Park, Pa. (W. E. Ranz, Dept. of Engineering Research, Pennsylvania State Univ., University Park.)

27–29. Heat Transfer and Fluid Mechanics Institute, Los Angeles, Calif. (M. Tribus, Univ. of California, Los Angeles.)

27–29. American Soc. of Heating and Air-Conditioning Engineers, San Francisco, Calif. (A. V. Hutchinson, 62 Worth St., New York 13.)

27–29. Symposium on Reproduction and Infertility, East Lansing, Mich. (E. P. Reineke, Dept. of Physiology and Pharmacology, Michigan State College, East Lansing.)

27–30. Annual Conf. on Aging, 8th, Ann Arbor, Mich. (Div. of Gerontology, Univ. of Michigan, 1510 Rackham Bldg., Ann Arbor.)

27–1. American Crystallographic Assoc., California Inst. of Technology, Pasadena.

Meetings & Conferences

June, *contd.*

27–1. American Inst. of Electrical Engineers, summer general, Swampscott, Mass. (N. S. Hibshem, AIEE, 33 W. 39 St., New York 18, N.Y.)

27–1. Assoc. of Official Seed Analysts, Stillwater, Okla. (R. G. Colborn, Seed Lab., Dept. of Agriculture, Lincoln, Neb.)

28–1. American Home Economics Assoc., annual, Minneapolis, Minn. (G. H. Johnson, 114 E. Park Pl., Newark, Del.)

28–9. British Instrument Industries' Exhibition, 3rd annual, London. (F. W. Bridges & Sons Ltd., Grand Bldgs., Trafalgar Sq., London W.C. 2.)

28–9. International Electrotechnical Commission, London, England. (American Standards Assoc., 70 E. 45 St., New York 17, N.Y.)

30–2. Acoustical Soc. of America, State College, Pa. (W. Waterfall, ASA, 57 E. 55 St., New York 22, N. Y.)

July

2–4. Astronomical League, Seattle, Wash. (G. C. Scholz, 166 Mason Hall Apts., Alexandria, Va.)

3–9. American Library Assoc., annual, Philadelphia, Pa. (D. H. Clift, 50 E. Huron St., Chicago 11, Ill.)

4–8. International Diabetes Federation, Cambridge, Eng. (IDF, 152 Harley St., London, W.1.)

13–17. International Seaweed Symposium, 2nd, Trondheim, Norway. (ISS, c/o T. Braarud, Blindern, Oslo.)

15–22. Assoc. Française pour l'Avancement des Sciences, Caen, France. (Mlle. Henri-Martin, Secrétaire, 28 rue Serpente, Paris 6e.)

18–23. International Assoc. of Applied Psychology, London, Eng. (C. B. Frisby, National Inst. of Industrial Psychology, 14 Welbeck St., London, W.1.)

18–23. International Water Supply Cong., 3rd, London, Eng. (L. Millis, 34 Park St., London, W.1.)

20–28. International Union of Pure and Applied Chemistry, Zurich, Switzerland. (R. Morf, Sec. Gen., IUPAC, Zurich 1.)

25–30. International Anatomical Cong., Paris, France. (G. Cordier, 3 Square Albani, Paris 16e.)

26–29. American Malacological Union, Staten Island, N. Y. (Mrs. M. C. Teskey, P.O. Box 238, Marinette, Wis.)

28–30. Colloquium on Biochemical Problems of Lipids, 2nd, Univ. of Ghent, Belgium. (R. Ruyssen, St. Jansvest 12, University of Ghent, Belgium.)

August

1–5. International Cong. of Plastic Surgery, Stockholm and Uppsala, Sweden. (J. F. Larsen, 12, Kristianiagade, Copenhagen Ø, Denmark.)

1–6. International Cong. of Biochemistry, Brussels, Belgium. (C. Liebeeq, 17 Place Delcour, Liége, Belgium.)

6–7. Linguistic Soc. of America, Washington, D.C. (A. A. Hill, 1719 Massachusetts Ave., NW, Washington, D.C.)

8–10. Inst. of Aeronautical Sciences, Seattle, Wash. (S. P. Johnston, IAS, 2 E. 64 St., New York 21.)

13–17. Canadian Teachers' Federation, Ottawa. (G. G. Croskery, 444 MacLaren St., Ottawa, Ont.)

15–18. American Veterinary Medical Assoc., Minneapolis, Minn. (J. G. Hardenbergh, 600 S. Michigan Ave., Chicago 5, Ill.)

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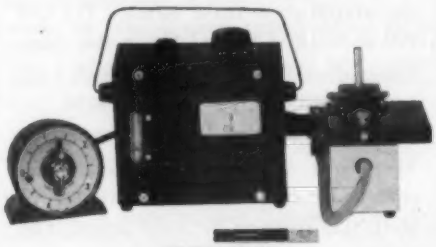

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Meetings & Conferences

August, *contd.*

15–19. American Institute of Electrical Engineers, Pacific general, Butte, Mont. (N. S. Hibshem, 33 W. 39 St., New York 18.)

15–19. American Soc. of Agronomy and the Soil Science Soc. of America, joint meeting, Davis, Calif. (L. G. Monthey, 2702 Monroe St., Madison 5, Wis.)

17–24. Australian and New Zealand Assoc. for the Advancement of Science, 31st, Melbourne, Australia. (J. R. A. McMillan, ANZAAS, Science House, 157 Gloucester St., Sydney, N.S.W., Australia.)

19–28. International Conf. of Agricultural Economists, Helsingfors, Finland. (J. R. Currie, Dartington Hall, Totnes, Devonshire, Eng.)

22–23. Electronics and Automatic Production Symposium, San Francisco, Calif. (Wm. D. McGuigan, Stanford Research Inst., Palo Alto.)

22–9. Wool Textile Research Conf., Sydney, Australia, (F. G. Nicholls, Commonwealth Scientific and Industrial Research Organization, 314 Albert St., East Melbourne, Australia.)

29–31. American Physical Soc., Mexico City, Mexico. (K. K. Darrow, Columbia Univ., New York 27.)

29–2. Infrared Spectroscopy Inst., 6th annual, Nashville, Tenn. (N. Fuson, ISI, Fisk Univ., Nashville 8.)

29–2. International Assoc. for Hydraulic Research, 6th plenary, Delft, Netherlands. (L. G. Straub, St. Anthony Falls Hydraulic Lab., Minneapolis 14, Minn., or J. Th. Thijsse, IAHR, Raam 61, Delft.)

29–3. Mathematical Assoc. of America, Ann Arbor, Mich. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

29–5. International Astronomical Union, Dublin, Ireland. (P. T. Oosterhoff, IAU, Leiden Observatory, Leiden, Netherlands.)

29–6. International Horticultural Cong., 14th, The Hague, Netherlands. (G. de Bakker, International Comm. for Horticulture, Bezuidenhoutseweg 30, The Hague.)

30–2. American Mathematical Soc., 60th summer, Ann Arbor, Mich. (AMS, 80 Waterman St. Providence 6, R.I.)

31–1. Conf. on Low Temperature Physics, Paris, France. (L. Weil, Institut Fourier, Place du Doyen Gosse, Grenoble, Isère, France.)

31–2. American Sociological Society, Washington, D.C. (W. J. Warner, ASS, New York Univ., Washington Sq., New York 3, N.Y.)

31–3. United Chapters of Phi Beta Kappa, 24th triennial, Minneapolis, Minn. (C. Billman, 1811 Q St., NW, Washington 9, D.C.)

31–7. British Assoc. for the Advancement of Science, annual, Bristol, Eng. (BAAS, Burlington House, London, W.1.)

31–8. International Cong. of Refrigeration, Paris, France. (L. Weil, Institut Fourier, Place du Doyen Gosse, Grenoble, Isère, France.)

September

1. Assoc. for Symbolic Logic, Ann Arbor, Mich. (J. Barlaz, Rutgers Univ., New Brunswick, N.J.)

2–7. American Psychological Association, San Francisco, Calif. (F. H. Sanford, APA, 1333 16 St., NW, Washington 6, D.C.)

Meetings & Conferences

September, *contd.*

2–7. Psychometric Society, San Francisco, Calif. (J. B. Carroll, Harvard Univ., 13 Kirkland St., Cambridge 38, Mass.)

4–7. International Congress of Vitamin E, 3rd, Venice, Italy. (K. E. Mason, Dept. of Anatomy, Univ. of Rochester School of Medicine and Dentistry, 260 Crittenden Blvd., Rochester 20, N.Y.)

4–11. International Cong. of Historical Sciences, 10th, Rome, Italy. (F. Chabod, X^e Congres International des Sciences Historiques, Université, Rome.)

5–6. American Political Science Association, Boulder, Colo. (H. C. Mansfield, Dept. of Political Science, Ohio State Univ. Columbus, Ohio.)

5–8. American Soc. for Pharmacology and Experimental Therapeutics, Iowa City, Iowa. (C. C. Pfeiffer, Dept. of Pharmacology, Emory Univ., Emory University, Ga.)

5–9. American Inst. of Biological Sciences, Michigan State College, East Lansing, Mich. (H. T. Cox, AIBS, 2000 P St., NW, Washington 6, D.C.)

5–9. Econometric Soc., Ann Arbor, Mich. (R. Ruggles, Box 1264, Yale Station, New Haven, Conn.)

5–10. World Cong. of Anaesthesiologists, Scheveningen, Netherlands. (W. A. Fentener van Vlissingen, WCA, Bilthoven, Netherlands.)

6–11. American Physiological Soc., Boston, Mass. (M. O. Lee, APS, 9650 Wisconsin Ave., Washington 14, D.C.)

7–9. American Soc. of Photogrammetry, Los Angeles, Calif. (C. E. Palmer, 1000 11 St., NW, Washington 1.)

9–10. Soc. of General Physiologists, Woods Hole, Mass. (J. B. Buck, National Institutes of Health, Bethesda 14, Md.)

11–16. American Chemical Soc., Minneapolis, Minn. (A. H. Emery, 1155 16 St., NW, Washington 6.)

11–16. Laurentian Hormone Conf. AAAS, annual, Estes Park, Colo. (Committee on Arrangements, 222 Maple Ave., Shrewsbury, Mass.)

11–16. Sigma Delta Epsilon, Minneapolis, Minn. (Mary Fojdics, Barat College, Lake Forest, Ill.)

11–18. International Cong. of Criminology, London, England. (State Univ. of New York, College of Medicine at New York City, 469 Clarkson Ave., Brooklyn 3.)

11–18. International Cong. of Librarianship and Documentation, Brussels, Belgium. (M. A. Baby, 8, Rue de Haguenau, Strasbourg, France.)

12–14. Soil Conservation Soc. of America, Green Lake, Wis. (H. W. Pritchard, 1016 Paramount Bldg., Des Moines, Iowa.)

12–16. Illuminating Engineering Soc., annual, Cleveland, Ohio. (A. D. Hinckley, 1860 Broadway, New York 23, N.Y.)

12–16. Instrument Soc. of America, 10th annual, Los Angeles, Calif. (Fred Tabery, 3443 S. Hill St., Los Angeles.)

13–15. American Meteorological Soc., Asbury Park, N.J. (K. C. Spengler, 3 Joy St., Boston 8, Mass.)

15–17. International Soc. for the Study of Biological Rhythm, 5th conference, Stockholm, Sweden. (Ture Petrén, Karolinska Institutet, Stockholm 60.)

19–23. Fédération Internationale Pharmaceutique, 16th general assembly, London, Eng. (D. F. Lewis, Secy., Organizing Committee, F.I.P., 17 Bloomsbury Sq., London, W.C.1.)

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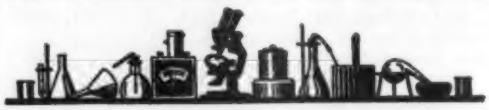

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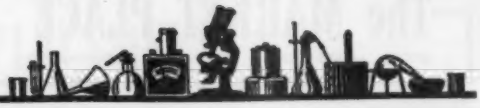

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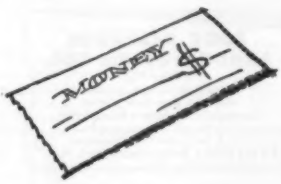

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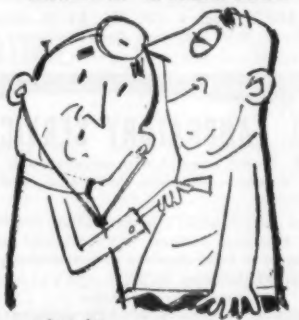

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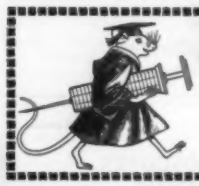

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